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WROUGHT IRON BRIDGE DESIGNS.

By WM. O. DOUGLAS, Binghamton, N.Y.

SOME time since, a writer commenting upon the causes of the failure of the bridge at Ashtabula, demanded that an iron bridge should be constructed in such a manner that the strength of the structure should not wholly depend upon the strength of any *single* member of the bridge, which is the case in all of the trusted forms of trusses for iron bridges.

The form known as the Pratt Truss is perhaps the most accepted for economy and strength for iron bridges, but its strength is dependent upon any one of several of its members, viz: Upon the suspension bars in the first panel, or upon first verticle, or top or bottom chords; if any one of these members rupture the structure will go down.

In the compound truss, above illustrated, we have the Pratt girder; also the arch and the suspension principles united to form an elliptical girder.

This compound truss may be so adjusted that the elliptical or the Pratt girder will do all of the work, while the other is at rest or without strain. Likewise it may be so adjusted that the elliptical or the Pratt Truss will be strained equally under a given load upon the bridge. In case of rupture in one truss of the compound girders, the other truss of that girder is sufficient to pass the moving load. Consequently, the strength of the structure is not dependent upon any single member of the truss.

It is quite understood that the strains increase in regular ratio from end to center as applied to the top and bottom chords of this double truss. It is also true that the strains increase in a similar manner from center to ends on the chords of the elliptical truss or the arch and cable, so that the aggregate chord strains of each panel throughout the compound truss are nearly equivalent.

The verticles are hollow wrought tubes. They are placed *between* and rest *upon* the chords. Their inside diameter at ends being reduced by a fillet to the size of the tie rod which passes through the verticles and the chords with a thread and nut adjustment at top and bottom of the truss. The aggregate strain upon the verticle, like those upon the chords, are nearly equivalent throughout the truss. For ordinary highway work the chords may be of a form as coming direct from the rolls of the mill. The two compressive chord members composed of channel or I bars and the two lower chord members of flat iron. There is economy here over those forms having but one compressive chord member which require the making of a box chord drilled, fitted, and riveted, to secure sufficient cross-section for compressive chord members.

In a bridge as above illustrated, in Fig. 2, we have the arch and suspension principles united, forming an elliptical truss. The thrust of the arch equipoises and is equipoised by the pull of the cable.

The roadway is suspended to the two chords so that the arch carries one half of the load and the cable the other, under which circumstances the thrust and pull at top of end posts will be equal.

The end posts have only to support the dead load of the bridge.

The floor suspension rods have no duty to perform beyond transmitting the roadway load to the sustaining members, and are only strained one panel load.

This bridge, while being loaded to its maximum capacity, will *raise up* along the floor line from first verticle to center load and all, which is equivalent to deflection in other forms of bridges when under heavy strain.

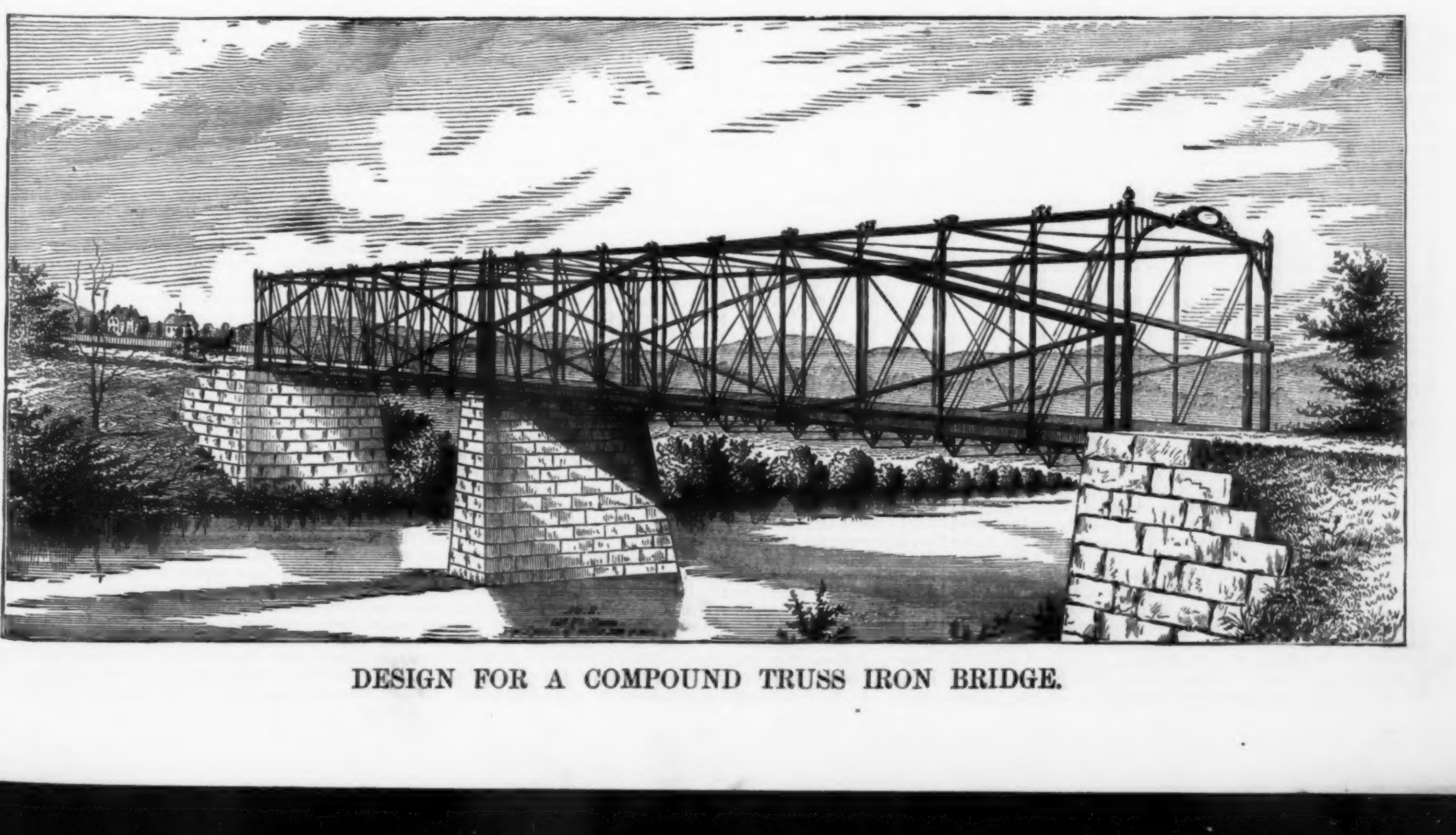
The verticles rest in iron seats *between* the chords, but are not fastened to the chords. Through the verticle, chord, and seat passes the floor suspender which preserves the compressive verticle in position; so from unequal loading the strain cannot alternate from tension to compression in this tie-strut.

In calculating the strains upon the chords of this elliptical truss, it is only necessary to assign one half of the load to the arch, and the other half to the cable, remembering that practically the verzine of the arch is the depth of the truss.

Criticisms of the general principles of this elliptical truss, positive and comparative, are respectfully invited from engineers over their signatures.

DESIGN FOR AN ELLIPTICAL TRUSS BRIDGE.

STEEL WIRE HAWSERS.—The iron-clad frigate Alexandra has a steel wire hawser in lieu of a hemp hawser; it is 150 fathoms long and weighs 1¼ tons, and occupies, when coiled, a space 4 ft. 6 in. by 4 ft. 6 in. A hemp hawser of the same strength would have to be 19 in., and of double the weight of the steel, and would occupy six times the space.



DESIGN FOR A COMPOUND TRUSS IRON BRIDGE.

CARLISLE BRIDGE, DUBLIN.

Carlisle Bridge occupies in Dublin a position analogous to that occupied by London Bridge in regard to metropolitan traffic—that is to say, Carlisle Bridge is the furthest down the river, and over it passes by far the greater part of the traffic between the north and south side of the city. The bridge has long been too small for its work, and it is now proposed to rebuild and widen it, according to plans prepared by Mr. Bindon Blood Stoney, M.I.C.E., engineer to the Dublin Corporation. We give an elevation thereof. The principal work consists in extending the piers and abutments of the present bridge, removing the old superstructure wing-walls, and quays, lowering and altering the approaches, and building a new and wide superstructure, with wing-walls and quays, on a portion of the old foundations, and on the extended piers, abutments, and wing-walls. The new work, east and west of the present bridge, is in the specification called the side additions.—*Engineer.*

HEALTH AND SEWAGE OF TOWNS.

THE PRACTICAL EXPERIENCE OF THE DRY SYSTEM.

By Alfred Carpenter, M.D. (London), C.S.S.

It is well-known that Croydon is drained in the ordinary way; that is, more or less imperfectly, but there are small areas which are not sewered at all. Among these is the hamlet of Waddon; it lies between Beddington and the southwestern part of the parish of Croydon. It is a district in which the water line is constantly changing, according to the requirements of the miller who works the water mill, which has existed from time immemorial at the confluence of the several small streams which give rise to the River Wandle. The occupiers of some of the fields close to the hamlet have also the right to dam up the Wandle, and use it as a sheep wash, and also the right to irrigate the pastures themselves. The result of the maintenance of these rights is that the subsoil is generally waterlogged, water existing within a few inches of the surface of the ground. Notwithstanding this state of things, a number of cottages were built on a part of this land close to the left bank of the principal stream of the Wandle. When the plans were first deposited by the speculators who proposed to erect these houses, there was no law by which they could be compelled to provide a dry basement. Application was made, by the builders to the local authority, to sewer that district at the public expense, but the Local Board declined to do it except at the expense of the owners. It was contended by the writer that the ratepayers of the parish ought not to be called upon to turn a swamp into building land for the benefit of speculators. Nevertheless, the houses were built, and immediately occupied by a swarm of poor. The result, which was predicted when the plans were deposited with the Local Board, soon came to pass. The inhabitants suffered continually from the effects of enthetic disease. Scarlatina, diphtheria, and fever were constant visitors. The neighbors then began to complain; many deaths occurred. The stench from the continually overflowing cesspools was plainly perceptible in the public road, and great pressure was brought to bear upon the local authorities to compel them to sewer the district, at an expense almost equal to the value of the cottages themselves. But it appeared to the writer that to put sewers into such a district would be a sanitary mistake, at least, one half of the time they would be waterlogged, and be the means of retaining mischief in close proximity to the houses, instead of conveying it away. It appeared that, before sewering the district, the water-line should be permanently lowered, that the owners should give up the right to flood the neighborhood, and thus make the land fit for building purposes, before the local authority provided sewers for the sewage. There was also another consideration in the case. The sewage from these cottages would have to be conveyed to Beddington sewage farm. There would then be a 12 inch sewer, constantly discharging subsoil water instead of sewage upon a farm which already receives more subsoil water than it is entitled to. The owners refused to do this duty, and it was left to the sanitary committee of the Croydon Local Board of Health to devise a remedy for the insanitary state of the hamlet, which state the law had allowed to grow up close to our own noses, and in spite of our protests. The year 1874 was a very fatal one to the inhabitants of the cottages; the owners did not—indeed, they could not—empty the cesspools which had been constructed, and it was evident that something must be done. The property had changed hands, and the new owners were willing to do what the Sanitary Committee recommended. The writer had been much struck with the simplicity and cheapness of Moser's closets, as exhibited at the Social Science Congress at Glasgow, in 1874, and ultimately 20 closets were erected by Mr. Moser, at a cost to the owners of something under £3 per closet. They were completed December 24th, 1874. The cottages are in a block close to the road, and about one third of a mile from the outfall sewer, near to which the town refuse of the Croydon district is conveyed. It was agreed with the owners that they should erect the closets, but that the Croydon Local Board should collect the refuse and supply the hoppers with dry ashes, and the pails with sawdust, as often as should be necessary. The whole of the arrangements were carried out, and have since been superintended by Mr. Mitchell, the sanitary inspector of the Croydon Local Board of Health, and I learn from him the following results: He states that, whereas serious illness always prevailed in those houses before the erection of the closets, there has been very little since, and scarcely any of that class of disease which formerly visited them; that the houses, instead of being pest-houses to the neighborhood, are now perfectly healthy. It is also stated in Dr. Buchanan's report upon the epidemic of fever, which visited Croydon in 1875, that these cottages at Waddon altogether escaped. Mr. Mitchell also states in a written report of last week's date:

"That he had had no complaints in writing at all. That there were a few verbal complaints at first, in consequence of the trouble that occupiers were put to whilst the workmen were about; but that they soon settled down, and that when they got used to the closets they expressed great pleasure at the change, stating that they were now free from the offensive smells to which they had been previously subjected, and that they now suffered no inconvenience, except when the men were late in removing the contents of (changing) the tubs."

It ought to be stated that almost frantic efforts were made to rouse the people against the use of the closets, and to compel the local authorities to sewer the district, and that a strong antagonistic feeling had to be contended against when they were first introduced.

The closet consists of a hopper at the back, large enough to receive a week's supply of earth or ashes (we use the latter from the siftings of the dust heap). By means of an exceedingly simple arrangement, the hopper discharges the ashes upon the solid fæces, as the user rises from the closet. The pail is placed beneath the seat. It consists of half a petroleum cask, well bound, with an upright diaphragm, which separates the anterior part of the pail from the posterior, the former being arranged to receive the urine, and is charged with sawdust. The pails are changed weekly, between five and six in the morning. The duty of collection is performed by one of the dustmen, who collects town refuse during the later hours of the day. The total cost for two years and a quarter, that is, to the end of March, 1877, has been as follows:

	£	s.	d.
Wages of man and boy....................	47	4	6
Horse and cart (use of).................	14	12	6
Sawdust..................................	8	9	0
Total cost for 118 weeks' collection	70	5	6

That is, £70 5s. 6d. appears in the accounts of the Local Board as the cost which the ratepayers have incurred during the last two and a half years in collecting and replacing the pails at Waddon. Against this sum there is a set-off in the value of the material collected. This is mixed with other refuse at the filtering house, and is sold with that refuse to market gardeners at 2s. 6d. a yard. It is probably worth rather more than that, but, not having been kept separate, its practical value is not known. About a yard and a half is collected every week, which reduces the actual cost by 3s. 9d., or to 8s. 3d. per week instead of 12s., which would appear to be the cost according to the published accounts. Twenty closets were erected in 1874, and two have been added since; thus 22 houses, occupied by 122 persons, have been provided for, the cost being £1 8s. 5d. per house, or 5s. 1½d. per person per annum; or, if we allow the value of the produce to be deducted, the cost is reduced to 3s. 6½d. per person, or to a trifle under £1 per house per annum. Of course, the experience of a small district puts the expense at an outside amount, and if, instead of 22 houses, there had been 220, the expense would be reduced by one half. I am inclined to think that 10s. per house would amply cover the cost of the collection of excreta in a country village of 200 houses, and if the average ratable value of the houses in such a village is put at £15, it would entail a rate of 9d. in the pound to provide for the removal of excreta by a dry earth plan. At the same time, there would be no debt incurred, and no mortgage of the rates necessary. I simply submit the facts for the consideration of the Conference.

It may be asked in what way the slops are provided for at the houses to which I have remained. When the closets were fixed, the cesspools were pumped out and the concrete broken down and communications between the closet and yard broken off, the waste pipes from the sinks were made to deliver upon a trapped grating in the yard which led by a drain into the old cesspool. From the cesspool, a filtering bed of loose stones and gravel, in a trench from where the drain pipes had been taken up, was provided, and this filtering bed led off to the River Wandle. Whenever the level of the water in the bed of the Wandle is below the level of this trench, it draws off into the Wandle without leaving the least trace of defilement or pollution. When the bed of the Wandle is full, the subsoil is necessarily filled with an impure water. If the Wandle was never dammed up, there would be no difficulty whatever on the score of the slop water; in the case in point and in most cases, if one of Field's flush tanks could be used, I see no reason whatever to suppose that any evil would arise at all, the only necessity being that houses should not be allowed to be erected on land which is water-logged.

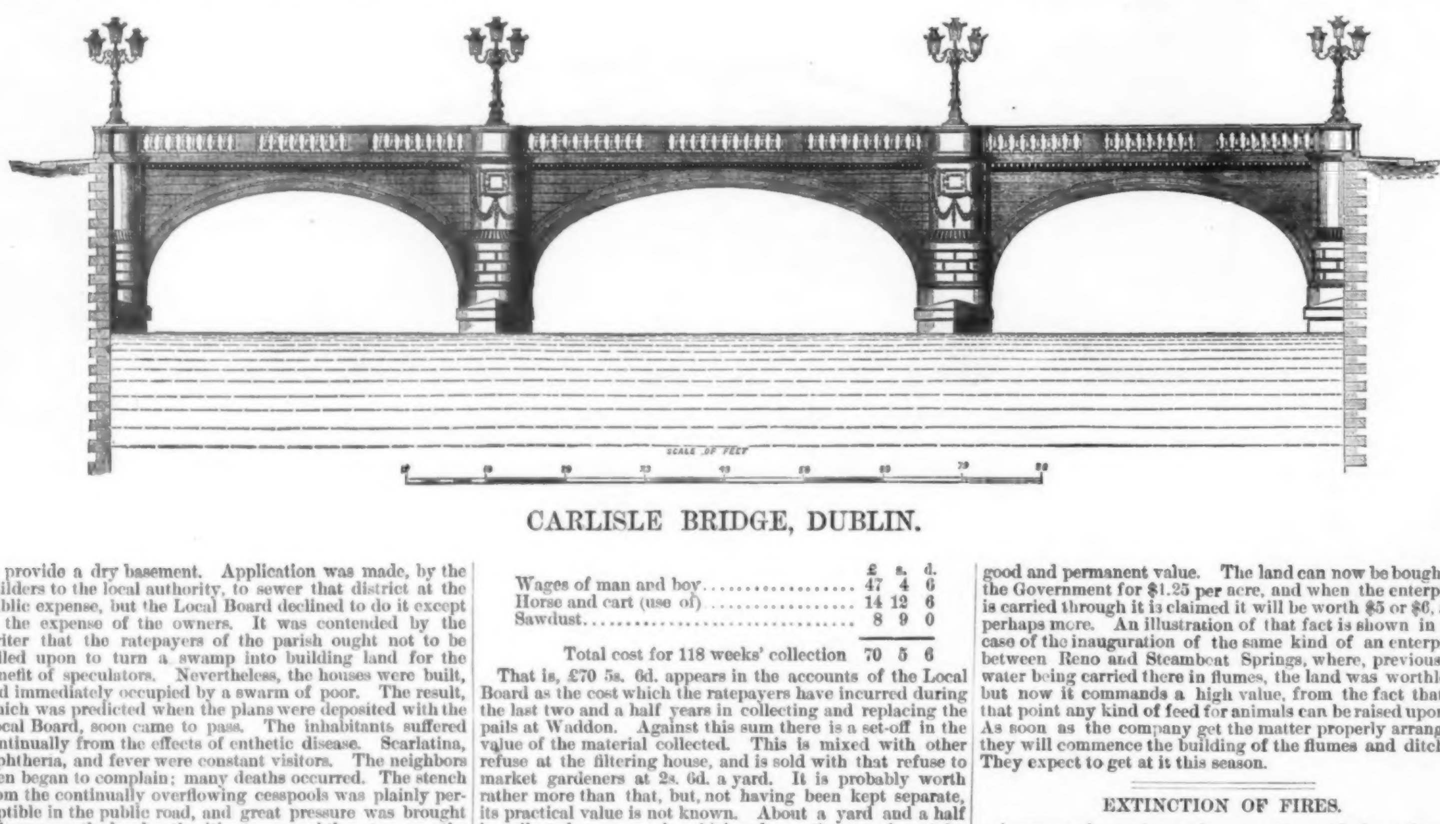
For small blocks of houses at a long distance from any system of sewers, or in thinly peopled districts, I can confidently recommend some such plan as that of Moser's as amply sufficient to prevent defilement of subsoil by sewage, and enough to provide for the removal of nuisance. But such arrangements must be under the control of a local authority, who must see that the proper removals are made at proper times.—*Journal of the Society of Arts.*

IMPORTANT DITCH ENTERPRISE.

The Nevada *Transcript* says: John Cashin, J. S. Thompson, J. D. Sweeny, M. M. Richardson, and J. H. Thomson, have filed a document in the County Recorder's office, setting forth that they have located and apropriated fifty thousand inches of water, running in Truckee River, measured under a four-inch pressure. They take it from the river at a point called Camp 20, in this county, at the dam of the "People's Ice Company." The purpose for which this water location is made is to convey the water of the Truckee River in a flume and ditches into Sierra County, in this State, and into Washoe County, in the State of Nevada, for floating wood, timber, and lumber; and more particularly for irrigating land. The flume and ditches will extend to Spanish Spring Valley, in Washoe County. The flume at the initial point will be constructed twelve feet wide on the bottom and four feet high on the sides, with two and one-half inches grade to the rod, and will be continued on a grade that will be necessary to convey the water to the agricultural lands lying north and south of the line of the flumes and ditches. The ditches and flumes will be of sufficient capacity to carry fifty thousand inches of water to the above-named point. They claim the right of way for their flumes and ditches over all lands lying along the line to the points above mentioned. The distance is about thirty miles. We understand the main idea in contemplation of this enterprise is to furnish water for irrigating the lands in that vicinity. There are thousands of acres there that are of no use to anybody in their present state, it being utterly impossible to utilize it without water, and the movement is projected to give it a good and permanent value. The land can now be bought of the Government for $1.25 per acre, and when the enterprise is carried through it is claimed it will be worth $5 or $6, and perhaps more. An illustration of that fact is shown in the case of the inauguration of the same kind of an enterprise between Reno and Steamboat Springs, where, previous to water being carried there in flumes, the land was worthless; but now it commands a high value, from the fact that at that point any kind of feed for animals can be raised upon it. As soon as the company get the matter properly arranged, they will commence the building of the flumes and ditches. They expect to get at it this season.

EXTINCTION OF FIRES.

A series of experiments in connection with the extinction of fires were carried out recently, by permission of the Commissioners of Woods and Forests, upon the vacant space of ground at the bottom of Whitehall Place, London. The improved fire exterminators, "Fire Queen" and "Double Express," are not charged until the moment arrives for using them, when by a blow upon the brass cap at their summit a bottle containing acid is broken, and a volume of carbonic acid gas, with a pressure of from 90 lbs. to 120 lbs. to the square inch, is generated. On the apparatus being emptied it can be speedily recharged by means of a fresh bottle of acid and a pocket of bicarbonate of soda. An open stockade of timber and tar barrels loosely packed together, about eight feet in height and twenty in length, having been liberally sprinkled with tar, was then set on fire. In two minutes it was blazing fiercely from end to end, and throwing out an amount of heat which drove all present to some distance. Two "Fire Queens" were brought to bear upon it, and in the space of a minute and a quarter the flames were utterly subdued. The woodwork having been recoated with naphtha was again ignited, and burnt, if possible, more fiercely than before, when the "Double Express" was brought to bear upon it with similarly successful results. The "Double Express," which has been expressly designed for use at railway stations, factories, and similar large buildings, present the peculiarity that one of the two cylinders composing it can be charged whilst the other is discharging its contents, by which means an uninterrupted flow of liquid can be poured upon the fire. The mask and goggles, fitted with Professor Tyndall's smoke respirator, and also with an air tube to enable the wearer to advance into the mines and other localities filled with noxious vapor, were also shown, and their working explained. Finally, the working of a new patent spiral descender, forming a portable self-acting fire escape, was ex-



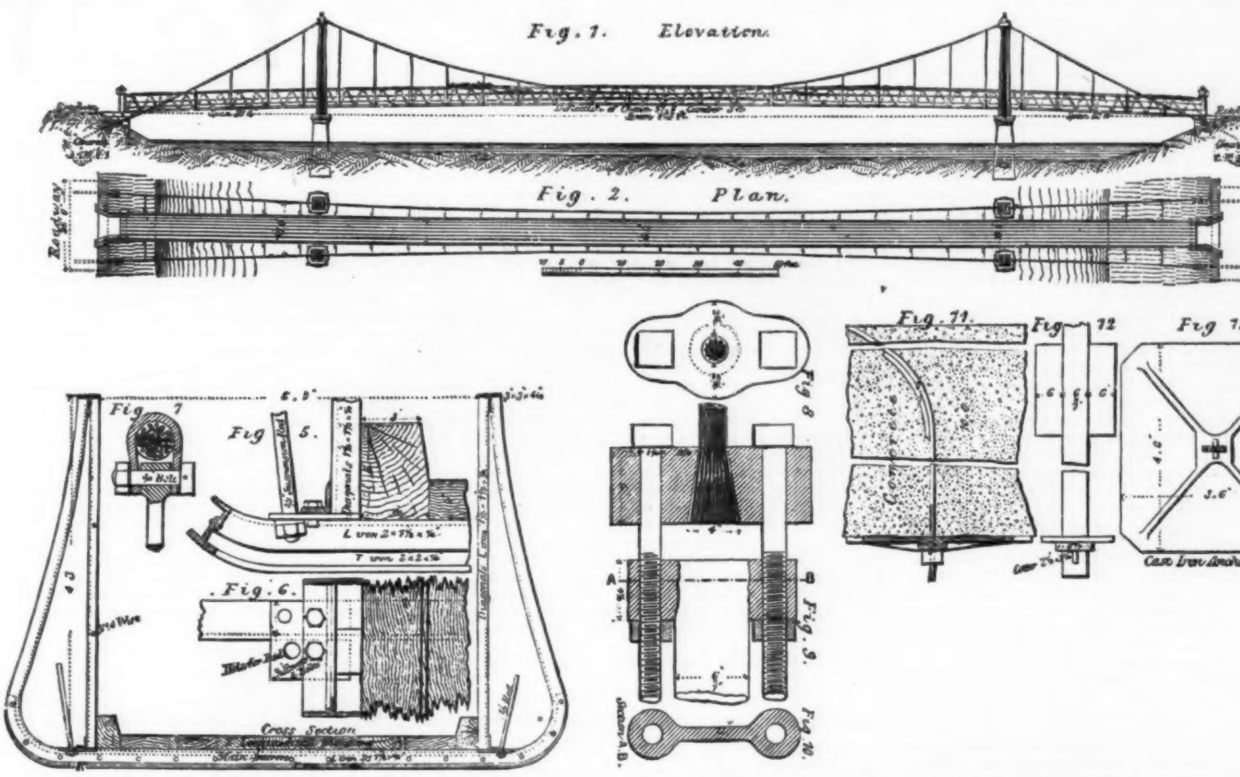
CARLISLE BRIDGE, DUBLIN.

hibited. This apparatus consists of a rope 60 feet in length, a girth or sling, and a species of spiral pulley, by means of which the person making use of it can regulate the rate of speed at which he descends, or check his progress at will in mid-air.

FOOT BRIDGE ACROSS THE RIVER NESS.

WE illustrate a foot bridge of extremely light construction recently erected across the River Ness, at Inverness, by Messrs. William Smith & Son, from the designs of Mr. C. R. Manners, of Inverness. The total length of the bridge is 273 ft., divided into two half spans of 50 ft. each, and one center span of 173 ft. The piers are formed of cast iron cylinders filled with concrete, and placed 13 ft. apart from center to center. Upon these cylinders two posts, 23 ft. 6 in. high to the bearing of the saddle, are placed. They are formed of a T-iron 5 in. by 2½ in. by 5/16 in. riveted to an angle iron 2½ in. by 2½ in. by 5/16 in. at each of the four angles, and placed 2 ft. 6 in. apart at the bottom, converging to 1 ft. 3 in. at the top. These standards are braced together by lattice bars 1¼ in. by 3/16 in., and the two posts are connected together at the top by light angle-iron brackets, to form the tower. Over the saddle on each post is placed a cast iron cap. The bridge is carried by two steel wire ropes 6 in. in circumference, and the ends are secured in a tapered hole formed in a cross bar, Fig. 8, through the ends of which, adjusting bolts 1⅜ in. diameter pass through the end of an anchor bar, 6 in. by 1 in., which goes through the concrete mooring block, 10 ft. by 10 ft. by 26 ft., and is held down by a cotter 2½ in. by 1¼ in. on the underside of a cast iron anchor plate 3 ft. 6 in. by 4 ft. A bearing plate 18 in. by 1 in. is introduced, where the anchor bar is bent round into a vertical position (Fig. 11). The suspension rods are 5/8 in. in diameter, and the attachment to the cables and girders is shown in Figs. 3 to 7. The former consists of wrought iron stirrups 2. in. by ⅜ in. passed over the cables, and projecting below it far enough to receive a ¾ in. bolt, on which is also placed the end of the suspension rod (Fig. 7). The bottom of the rod is bolted to a small plate bracket 4 in. by 4 in. by ⅜ in. attached to the bridge girders (Fig. 5 and 6). The longitudinal girders carrying the floor are 4 ft. 3 in. deep, and are formed, the top number of a T-iron 3 in. by 3 in. by 5/16 in., and the bottom of an angle iron 2½ in. by 1½ in. by ½ in. connected by angle iron diagonals 1¼ in. by 1¼ in. by ¼ in. The flooring is carried by cross beams of two angle irons riveted together 2 in. by 1½ in. by ½ in. at intervals of about 9 ft., and with intermediate joists of single angle irons 3 in. by 1½ in. by ½ in. One of the angle irons of the stronger beam is brought up and attached to the top member of the girder (Figs. 3 and 4). The floor, which is 6 ft. wide, is composed of 2 in. planking, with sills on each side 5 in. by 3½ in.

This bridge, which is the first of two to be erected across the Ness by the same engineer, was opened for traffic last summer. The total cost of the structure was £1,001, the amount having been subscribed by the townspeople of Inverness.—*Engineering.*



FOOT BRIDGE OVER THE RIVER NESS AT INVERNESS. BY C. R. MANNERS, ENGINEER.

THE NEW GERMAN PATENT LAW.

The following is a translation of the new German Patent Law:

FIRST SECTION.—PATENT RIGHTS.

Patents are granted for new inventions which admit of industrial use. Excepted are—(1) Inventions the use of which would be incompatible with the laws of the public morals; (2) inventions of articles of food—for nourishment or luxuries—of medicines and of substances produced by chemical process, so far as the invention does not relate to a certain method of producing such articles.

2. An invention is not regarded as new if it has already been described in any printed publication, or publicly used in Germany at the time of application for a patent in accordance with this law, in such a manner that its employment appears possible by other persons skilled in the particular trade to which it relates.

3. Whosoever first applies for a patent of invention according to the provisions of this law is entitled to the grant of the same. The claim of the petitioner to the grant of a patent is void if the essential contents of his application have without permission been taken from the descriptions, drawings, models, implements, or arrangements of another person, or from a method of manufacture used by the same, and if such person raises opposition on that account.

4. The patent has the effect that nobody is permitted to manufacture professionally—*gewerbsmässig*—to introduce into commerce, or to sell the article to which the invention relates. If the invention relates to a method of manufacture, to a machine, or other mechanical contrivance, to a tool or other implement, the patent has moreover the effect to prohibit any one from applying such method or of using the article to which the invention relates without permission of the inventor.

5. The patent has no effect against a person who, at the time the patentee made his application, had already been using the invention in Germany, or who had made the necessary preparations for using the same. The patent, moreover, has no effect in so far as the invention is intended to be used by order of the Imperial Chancellor for the army or navy, or in the interest of the public welfare. In such a case the patentee is, however, entitled to an adequate compensation by the Empire or the State in whose special interest the limitation of the effect of the patent has been applied for. The amount of such compensation shall be fixed by a court of law in case an agreement cannot be arrived at. The patent has no effect upon arrangements in means of conveyance—*Fahrzeuge*—which come but temporarily within the boundaries of the Empire.

6. The claim to the grant of a patent and the patent rights themselves pass over to the heirs. The claim and the patent rights may be transferred partly or totally to other persons by agreement or by will.

7. The duration of a patent is fifteen years, the term commences with the day following the day of application. If an invention is an improvement upon another invention patented in favor of the applicant, the latter may apply for a supplementary patent, which expires with the patent for the original invention.

8. At the issue of a patent a fee of 30 marks is to be paid. Except in the case of supplementary patents (paragraph 7), a further fee must be paid for each patent at the commencement of the second and every subsequent year, amounting, in the first instance, to 50 marks, and increasing by 50 marks per annum for the time of duration of the patent. A patentee who proves his want of means may have a respite in the payment of the fees for the first and second year until the third year, and if the patent expires in the third year, they may be remitted entirely.

9. A patent expires if the patentee resigns the same, or if he fails to pay the fees within three months at the latest after they have become due.

10. A patent shall be annulled if it is found :—(1) That the invention was not patentable according to paragraphs 1 and 2. (2) That the essential contents of the application had, without permission, been taken from the descriptions, drawings, models, implements, or arrangements of another person, or from a method of manufacture used by the same.

11. A patent can be revoked after the expiration of three years :—(1) If the patentee fails to carry out his invention in Germany to a suitable extent, or at least to do everything that is necessary to insure its being carried out. (2) If the grant of license to others for using the invention appears to be demanded in the interest of public welfare, but the patentee, nevertheless, refuses to grant such license upon an adequate compensation and against sufficient security.

12. Any person not residing in the Empire can only advance his claim to the grant of a patent and to the rights resulting therefrom in case of the appointment of a representative resident in Germany. The same is authorized to act in all proceedings by virtue of this law, as well as in civil law suits concerning the patent. In cases of litigation against the patentee, the court in the district of which the representative has his domicile, but if there be no representative, the court of the district in which the Patent-office has its seat, is clothed with jurisdiction.

SECOND SECTION.—PATENT OFFICE.

13. The granting of patents, the annulment and the revocation of the same, is vested in the Patent-office. The Patent-office has its seat at Berlin. It consists of at least three permanent members, including the chairman, and of non-permanent members. The members are appointed by the Emperor; the other officials by the Imperial Chancellor. The permanent members are appointed on nomination by the Federal Council. If they hold an office of the Empire or of a State, the appointment will be for the term of such office, in other cases for life—the appointment of the non-permanent members will be for five years. Of the permanent members at least three must have the qualification for the office of a judge or superior official of the Administration; the non-permanent members must be expert in some branch of technical science. The regulations in paragraph 16 of the law of May 31st, 1873, concerning the legal position of imperial officials, does not apply to non-permanent members.

14. The Patent-office consists of several departments. These are formed in advance for at least one year. Any member may hold office in several departments. In case of the granting of a patent, the quorum of any department must not be less than three, among whom there must be two non-permanent members. In the case of decisions regarding the nullity and the revocation of patents, a special department shall be formed. For decisions of this department, a quorum is required of two members, including the chairman, who have the qualification for the office of a judge or superior official of the Administration, and of three other members. The provisions of the code of civil law with regard to the exclusion or refusal of members of court apply to the members of the Patent-office. Experts who are not members may be invited to attend at legal proceedings, but they are not entitled to vote.

15. The resolutions and decisions of the departments are issued in the name of the Patent-office; they must be made out in writing with statement of the arguments; and a copy of the same must be delivered officially to each of the interested parties. Notifications by which special terms are fixed will be sent by post in a registered letter against receipt. If a notification cannot be delivered within the country, it will be forwarded by the appointed official of the Patent-office by post, in accordance with the provisions of the paragraphs 161 and 175 of the code of civil law. The decisions of the Patent office are subject to appeal.

16. If the decision of a department of the Patent-office is made the subject of complaint, such complaint shall be submitted to the decision of another department or of several departments jointly.

17. The organization of the departments, the regulation of their spheres of duty, the form of procedure, and the order of business of the Patent office, will be determined by an imperial order with assent of the Federal Council, in so far as these points are not regulated by the present law.

18. At the request of the Law Courts the Patent-office is bound to give opinion in all questions concerning patents. The Patent-office is in no other case authorized to pass resolutions or to deliver opinions foreign to its legal business sphere without special leave of the Imperial Chancellor.

19. A register will be kept at the Patent-office, in which the subject-matter and the duration of granted patents will be entered, as well as the name and address of the patentees and of the representatives appointed by them on presentation of their applications. The commencement, the termination, the expiration, the decree of annulment, and the revocation of patents must be entered in this register, and simultaneously published in the *Reichsanzeiger*. Should a change take place in the ownership of a patent, or in the representation of the patentee, such fact will likewise be entered in the register and publicly notified by the *Reichsanzeiger* if brought to the knowledge of the Patent-office in duly testified form. As long as this is omitted, the former patentee and his former representative remain authorized and liable according to the provisions of this law. The inspection of the register, and of the specifications, drawings, models, and specimens on the basis of which patents have been granted, is open to everybody, unless the patent concerned has been taken out in the name of the Imperial Ad-

ministration for purposes of the army or navy. The essential parts of specifications and drawings, so far as their inspection is permitted to the public, will be published by the Patent-office in an official paper. Therein will also appear all the notifications which must be published by the *Reichsanzeiger*, in accordance with this law.

THIRD SECTION.—PROCEEDINGS IN PATENT MATTERS.

20. The application for the grant of a patent for an invention must be made in writing to the Patent-office. For each invention a separate application is required. The application must contain the petition for the grant of a patent, and must point out in a precise manner the subject-matter which is to be patented. In a separate form the invention must be described in such manner, that thereby the employment of the same by other persons versed in the particular trade to which it relates, appears possible. It shall also be accompanied by the necessary drawings or other representations, models, and samples. The Patent-office will issue regulations with regard to other requisites of application. Up to the time of publication of the application it will be permitted to amend or alter the specification. On filing the application a fee of 20 marks must be paid for the cost of the proceeding.

21. Should an application be defective with regard to the prescribed requirements, the Patent-office will point out to the petitioner the defects, and demand of him the amendment within a specified time. Should this demand not be met with in a given period, the application will be rejected.

22. In case the Patent-office considers that the application has been made in due form, and that there is no apparent objection to the granting of a patent, it will order the application to be published. From the date of publication, the subject matter of the application will be provisionally protected in favor of the petitioner, according to paragraphs 4, 5. If the Patent-office is of opinion that the invention cannot be considered as patentable, according to paragraphs 1 and 2, the application will be rejected.

23. The *Reichsanzeiger* publishes once the name of the petitioner and the chief points of his claims. At the same time the application and accompanying papers will be laid open at the Patent office for public inspection, and a notice inserted to the effect that the subject-matter of the application is provisionally protected against unauthorized use. In case the Imperial Administration request a patent for military or naval purposes, the application and accompanying papers will not be subject to public inspection.

24. After expiration of eight weeks from the day of publication—paragraph 23—the Patent office has to resolve as to granting of the patent. Until that day objections against the granting can be lodged at the Patent-office. They must be made in writing, and be accompanied by arguments which, however, can only be based upon the ground that the invention is not new, or that it comes under the suppositions of paragraph 3, clause 2. Before finally deciding, the Patent-office may summon both parties to attend and be heard; it may also cause the objections to be examined by suitable persons skilled in some branch of technical science, and otherwise institute inquiries for elucidating the matter.

25. Against a decision by which an application is rejected the petitioner may appeal within four weeks after its notification, and against the decision concerning the granting of the patent the petitioner or the opponent may appeal within the same time. On filing the appeal 20 marks must be paid for the cost of the proceedings; should payment not be made the appeal will not be taken into consideration. On the proceeding, paragraph 24, clause 2, is applicable.

26. As soon as the granting of a patent has been definitely decided upon, the Patent-office will cause a notice to that effect to be published in the *Reichsanzeiger*, and then issue a document for the patentee. If a patent is refused this will also be publicly notified. Upon the refusal, the provisional protection shall be considered as not having taken effect.

27. Proceedings with regard to annulment or the revocation of a patent will only be instituted upon a motion. In cases provided for by paragraph 10, clause 2, only the injured party shall be entitled to forward such motion. The motion must be directed in writing to the Patent-office, and must contain the facts upon which it is based.

28. After the institution of proceedings has been ordered, the Patent-office will inform the patentee of the motion, and request him to deliver his answer to the same within a term of four weeks. Upon default of the patentee the decision may ensue according to the motion without summoning and hearing the parties, and for such decision all the facts asserted by the mover may be considered as proved.

29. If the patentee lodges his reply in due time, or if, in the case of paragraph 28, clause 2, the motion is not decided upon immediately, the Patent office will issue the necessary orders for investigating the matter, and, moreover, in the first case communicate the reply to the mover. It may also cause witnesses and experts to be examined. In this respect the regulations of the code of civil law will apply. The depositions must be taken down in writing by a sworn recorder. The decision will be given after the parties interested have been summoned and heard. In case motion is made for the revocation of the patent on the basis of paragraph 11, clause 2, the decision must be preceded by a warning with respect to the revocation of the patent, accompanied by the reasons therefor, and a suitable time will be fixed after which the revocation may take place.

30. In this decision (paragraphs 28–29) the Patent-office has power to fix the amount of costs to be paid by either of the parties to the suit.

31. It shall be the duty of the law-courts to render all legal assistance to the Patent-office. Upon special motion they will inflict fines on witnesses and experts who have failed to appear, or who decline to answer or to swear to their depositions; and, moreover, they will cause such witnesses as have not appeared to be brought before the office.

32. Against the decisions of the Patent office (paragraphs 28 and 29) an appeal is allowed. Such appeal will be heard by the Imperial Supreme Court of Commerce. It must be presented in writing to the Patent office, with a statement of the reasons, within six weeks after communication of the decision. In the sentence of the court the costs of the proceedings shall be fixed in accordance with paragraph 30. In all other respects the proceedings in court will be determined by special regulations, to be drawn up by the court, and promulgated by Imperial ordinance, with the assent of the Federal Council.

33. Regarding the official language of the Patent-office, the provisions of the law concerning the organization of the law-courts, and the language to be used before them, are to be observed. No action will be taken upon applications which are not written in the German language.

FOURTH SECTION.—FINES AND DAMAGES.

34. Whoever knowingly makes use of an invention in violation of paragraphs 4 and 5 shall be liable to a fine not exceeding 5,000 marks, or imprisonment not exceeding the term of one year, and shall be bound to pay damages to the aggrieved party. Penal proceedings will only be instituted on motion being made to that effect.

35. If judgment is passed in penal proceedings, the aggrieved party will be authorized to publish the judicial decision at the expense of the defendant. The manner of publication, and the time within which the same must be effected, shall be fixed in the decree.

36. Instead of damages to be awarded according to the provisions of this law, the court may, on the request of the aggrieved party, adjudicate, besides the ordinary fine, a payment of compensation not exceeding 10,000 marks. For this amount all defendants shall be jointly liable. Such compensation being adjudicated, all further claims for damages will be excluded.

37. The competency of the Imperial Supreme Court of Commerce regulated by paragraph 12 of the law of June 12th, 1869, concerning the establishment of a supreme court of commercial affairs, shall be extended to such civil lawsuits in which by action a claim is advanced on basis of the provisions of this law.

38. The term within which an action may be brought for an infringement of patent right is limited to three years with regard to any single case by which such action may be supported.

39. The question whether damage has been caused, and to what amount, will be decided by the court according to unbiassed conviction after due consideration of all circumstances.

40. Sentence will be passed for payment of a fine not exceeding 150 marks or imprisonment: (1) Or any person placing on articles, or their packing, any designation calculated to cause the erroneous impression that such articles are protected by a patent in accordance with this law. (2) On any person who in public advertisements, on sign boards, on business cards, or in similar notifications, employs a designation calculated to cause the erroneous impression that the articles thus mentioned are protected by a patent in accordance to this law.

FIFTH SECTION.—TRANSITORY RULES.

41. The patents in force at the present time by virtue of State laws shall remain valid according to the provisions of such laws until their expiration; but no prolongation of their term shall be granted.

42. The holder of an existing patent—paragraph 41—may claim the grant of a patent by virtue of this law, for the invention protected by the former. The examination of the invention in such case is subject to the form prescribed by this law. The patent shall be refused if the holder of another patent in force for the same invention—paragraph 41 claims the grant of a patent, or raises opposition against the grant before such grant has been decided upon. For want of novelty the granting of the patent shall be refused only in case the invention was not new in the sense of paragraph 2 at the time when first patented in Germany. On the granting of a patent in accordance with this law all patents in force for the same invention (paragraph 41) shall become void if they are in possession of the holder of the new patent. If this is not the case, the new patent will not take legal effect in the district in which the existing patent is valid before the expiration of the latter.

43. The time during which an invention has been protected in Germany by the eldest of the patents in force shall be deducted from the legal period of duration of the patent granted according to paragraph 42. The patentee shall be bound to pay for the remaining term of his patent the legal fees (paragraph 8). The date of payment and annual amount of the fees shall be fixed according to the time at which protection was first granted to the invention in Germany.

44. By the grant of a patent according to paragraph 42, persons who had already been using the invention without infringement of a patent right at the time a patent for the same was applied for, or who had made the necessary preparations for using the same, shall not be precluded in such use.

45. This law shall come into force on the 1st of July, 1877.

RADIATING STEAM HERCULES FOR THE ST. HELIERS' HARBOR WORKS.

Until a few years ago, the blocks of most harbor works were set from a temporary stage of timber, which not only entailed a great first cost, but was also exposed to a great deal of risk from heavy seas. The first idea of setting blocks off the end of the work as it progressed is due, we believe, to Mr. Parkes, who employed for the works of the Kurrachee Harbor a lifting appliance called a "Titan," which consisted of two overhanging girders with a traveler running along the top. In setting the piers of the North Sea Harbor, Messrs. Lee, the contractors, used a radiating machine, which laid the 10-ton blocks off the end. This idea of Messrs. Lee has been adopted by Sir John Coode in designing the "Hercules," as he terms it, for the St. Heliers' Harbor Works, Jersey; this appliance is made very large and strong, so as to take blocks of 15 tons, and set them, with a great overhang.

The accompanying engravings give both side and end elevations of this machine, which, as will be seen, radiates on a back pivot; the radiating framework bears upon six wheels working on a steel rail bent in the form of a segment of a circle, the chord of the arc of radiation being 50 ft. The wheels, cast of crucible steel, are placed underneath the front frame; the load, consisting of 15-ton blocks, is lifted in the bite of a 1 in. chain, the carriage supporting the pulley being racked in and out over the girders by means of an endless steel wire rope. The whole machine is propelled along a line of way having a gauge of 24 ft; there is thus sufficient space, as well as headway, for the passage underneath of locomotives and trucks conveying blocks to the extreme end of the work, where the latter are to be lifted by the Hercules before being laid in position. All the motions for propulsion, lifting and lowering blocks, and racking the carriage in and out, are given by a pair of horizontal engines, which, with their vertical boiler and feed tank, serve to counterbalance the overhang; any additional balance required being placed in the tank or on the tail end of the machine. These various motions are under the easy control of one man, who is also able to attend to the firing of the boiler.

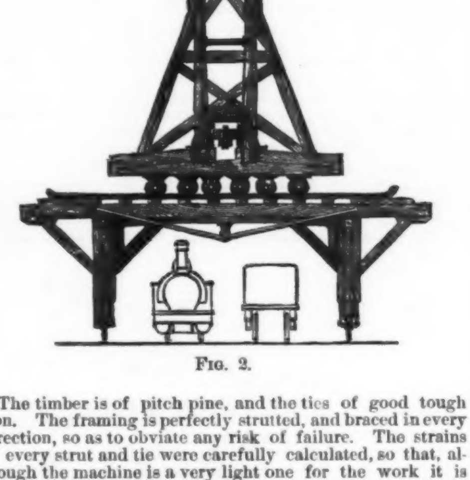
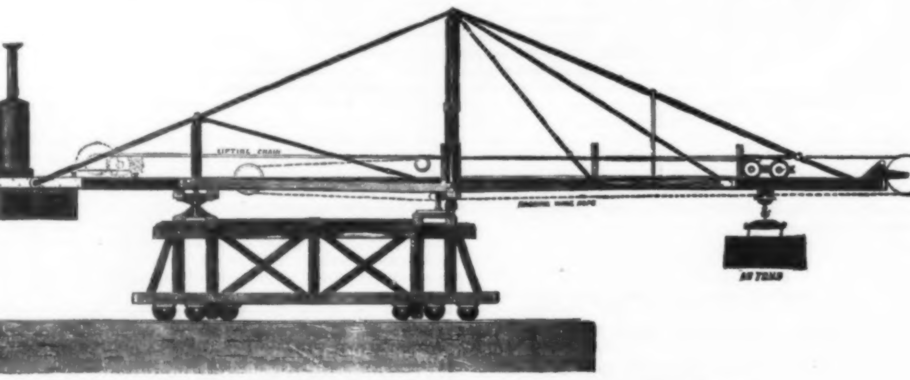


Fig. 2.

The timber is of pitch pine, and the ties of good tough iron. The framing is perfectly strutted, and braced in every direction, so as to obviate any risk of failure. The strains of every strut and tie were carefully calculated, so that, although the machine is a very light one for the work it is called upon to perform, it has been found very steady in actual operation. It also works with great ease, of which fact a curious proof was soon afforded. The radiating frame, although 120 ft. long, and driven by worm gearing, turned so readily that it was blown round by the wind; and Mr. Imrie Bell, the resident engineer, therefore found it necessary to add a brake to check this tendency. It is the practice to run the machine back every night on the completion of the day's work, so as to be out of the reach of any sudden gales. The Hercules has been in constant work for twelve months, and continues to give the most satisfactory results.—*Engineer.*



THE RADIATING STEAM HERCULES.—Fig. 1.

NEW MEAT TRUCKS.

The Caledonian Railway Company, England, have just had built for them eight special trucks or carriages for the conveyance of the American fresh meats. Each truck has a double room, and through the space between these roofs the fresh air is carried into the body of the carriage where the meat in quarters is suspended. It is consequently exposed to a continuous draught of fresh air, which must necessarily improve the tenderness of the meat.

Railway Sleepers.—A patent has been taken out, which consists in making the transverse sleepers of cast iron, with recesses for short blocks of wood, on which are fastened the chairs which support the rails, it being claimed that the perishable substance is reduced to a minimum, and that the inherent elasticity of the wood is not checked, or its effect contracted.

Steam Hand Car.—Master Mechanic Minshull, of the New York and Oswego Midland Railroad, has built for inspection purposes a "steam hand car." It has an upright boiler and engine, which is several horse-power. The engine has a nine-inch stroke and the cylinder a four-inch bore. It will run the car about thirty miles an hour.

New Horse Shoe.—Mr. Yates, of Manchester, has invented a horse-shoe, composed of three thicknesses of cowhide, compressed into a steel mould, and then subjected to a chemical preparation. It lasts longer, and weighs only one-fourth as much as the common shoe; it never splits the hoof and has no injurious influence on the foot. It requires no calks; even on asphalt the horse never slips. It is so elastic that the horse's step is lighter and surer. It adheres so closely to the foot that neither dust nor water can penetrate between the shoe and the hoof.—*Les Mondes.*

SCOTT'S WHEEL CUTTING AND MOULDING MACHINE.

FOR the purpose of dividing circles with ease and accuracy into any required number of equal divisions, as is necessary in wheel-moulding, wheel-cutting, and many other machines, the inventor of this apparatus, Mr. J. C. Scott, of Manchester, England, has, with great simplicity, adapted a thoroughly mechanical and theoretically perfect arrangement for the attainment of his object.

Fig. 1 shows one of the usual forms of Mr. George L. Scott's wheel-moulding machines, of the old and well-known style, but altered by the removal of the change-wheel apparatus, and the substitution of the new arrangement, which has been designed by his son. Fig. 2 shows the new form of the machine as now constructed from the latest designs, in which the patent dividing apparatus and a new movement to the sliding beam are combined. Fig. 3, on the opposite page, shows the application of the same patent dividing apparatus, as applied to a very neatly designed and thoroughly well-made wheel-cutting machine.

The invention itself, speaking strictly, consists in the application of a small hinged stop carried by a movable slide placed on the edge of a plate wheel or disk, about 10 in. in diameter, which is clearly seen in each machine. This disk is a fixture, and through its center works the spindle and worm which gears into the master worm-wheel of the machine, the spindle being turned as may be needed by the handle seen in front. The worm-wheel may be of any convenient size and pitch, but must, of course, be thoroughly well cut to reproduce good work. The worm wheels in the machines we illustrate have been made with 200 teeth, but there is nothing to prevent any other number of primary divisions being employed. The handle shown on the end of the worm spindle has a spring catch in it, which slips into a notch cut for its reception in the face of the disk, when the handle is in its normal position as shown; the handle is also so arranged that it can be made loose, or firmly grip the worm spindle at the will of the operator using the machine, by simply turning a small handle and screw as shown in Fig. 1, or by the longitudinal movement imparted to the central pin shown in Fig. 2, in which case the handle is hinged for this purpose at about midway of its length. In each case the effect is the same, and the handle may be made to slip freely on the spindle, or to turn the spindle as may be desired. It is evident, therefore, that, if the handle be made to grip the spindle and one complete turn be given to it, the resulting movement will be that the machine will have been moved in exact accordance with the division of the worm-wheel, or one 200th of the circumference of a circle, and would, therefore, in a wheel-moulding machine, as Fig. 1, be suited for making a wheel with 200 teeth. But if a wheel of only 100 teeth were required, it is equally evident that two turns of the handle would produce the required result. But if 201 teeth were needed, or any number greater than 200, the handle must be moved something *less* than one entire revolution; and, if less than 200 teeth be required, the handle must make something *more* than one revolution. For properly attaining this purpose, the periphery of the disk is carefully divided into 1,000 parts, which are clearly marked upon it by fine lines.

The movable slide with its little hinged stop, can be set to any one of these divisions, or even, if need be, between any two of them, though such accuracy will be practically unnecessary. Thus for a division for 100 teeth the handle must be made to turn the spindle two entire turns, that is, $\frac{200}{100} = 2$; for 150 teeth $\frac{200}{150} = 1·333$ turns; for, say, 157 teeth $\frac{200}{157} = 1·2738$ full or 1·2739 nearly; for 201 teeth $\frac{200}{201} = 0·995$, the error either way being something less than $\frac{1}{200000}$th of the circumference.

But to render this system of measurement, which in itself is not new, practically useful for the purposes named, we find the movable hinged stop and the loose movement of the handle, or the patented portions of the apparatus, applied. Taking the first example (100 teeth), the handle would simply be made to take two turns, that is, from the notch round to the notch, twice to produce the first division. In the second case, the movable slide would have to be "set" with the face of the hinged stop at the division line 0·333, or at ⅓ of the way round the disk from the notch, and being thus set the hinged stop must be turned back out of the way so as to allow the handle to pass it on its first turn, but must be put down so as to stop the handle at that precise point on its second turn. Then the spindle should be fixed in its position by the "set screw" seen best in Fig. 2, while the handle is set free from the spindle (as before described) and passed backwards from the stop to its normal position. When again tightened on the spindle and the side "set screw" is slackened, the next division can be produced in like manner. In short, the action may be described as consisting of "a turn," or "turns," or "a part of a turn," or "a turn and a part of a turn," or "turns and a part of a turn."

It will easily be understood how this system of subdivision may be carried to any desired degree of exactitude, by the increase of the number of teeth in the master wheel, and by the enlargement of the disk and the increase of the divisions upon its periphery, or, if needed, by the change of the disk into a second master wheel, and the application of the disk to it as before, by means of which the minuteness of the divisions could be carried to any extreme short of infinite. We have made personal examination of some of these machines, and have found them giving great satisfaction both to the owners and to the workmen using them.

The care required in the use of these machines is no greater than that which is necessary in any others of a similar nature. The application of the patented stop, and the loose return motion of the turning handle, is exceedingly simple. It will have been noticed that one of our examples (201 teeth) is a case of a prime number, the production of which by any combination of change wheels not having over 201 teeth among them is simply impossible from a master wheel with 200 teeth, except with a partial movement of the handle to some point other than its normal stopping-place, which said point would change and need to be carefully remeasured each time the required movement from tooth to tooth is to be made.

In the new arrangement, however, the measurement is once, and only once, made for each wheel that has to be moulded, cut, or divided, and the pitches or divisions that are formed will be absolutely equal from first to last, and any number of divisions may be made from 2 up to 200,000 by the disk as supplied, or to higher numbers if needed, without a single change wheel. The useful application, therefore, of the invention cannot fail to be appreciated, and should tend to a great extension of the use of wheel-moulding and wheel-cutting machines, and the consequent improvement in all classes of machinery in which toothed wheels are employed.—*Engineering.*

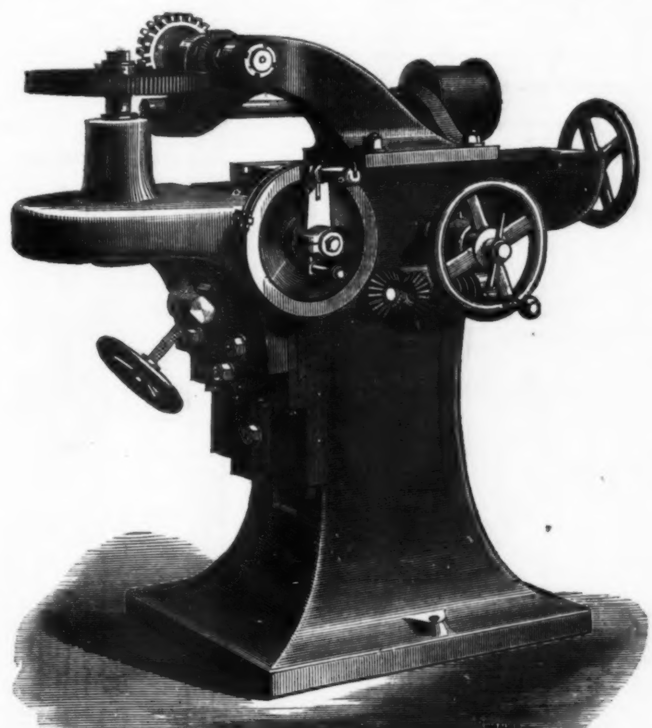


FIG. 3.—SCOTT'S WHEEL-CUTTING MACHINE.

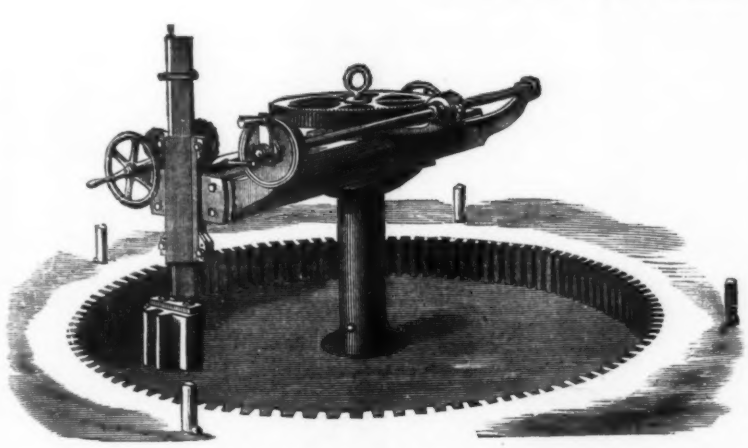
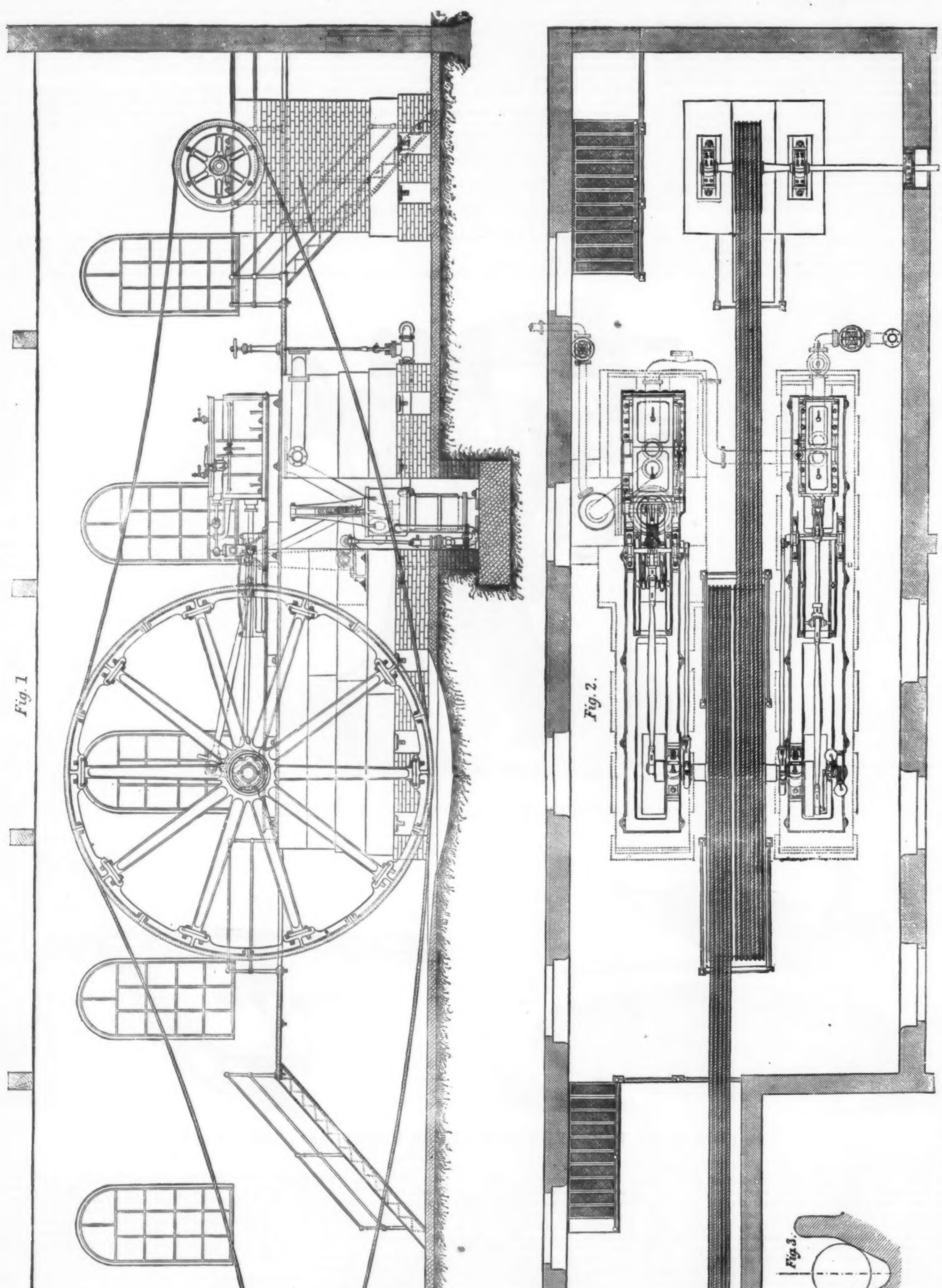


FIG. 1.—SCOTT'S IMPROVED WHEEL-MOULDING MACHINE.—FIG. 2.

THE Delameter well, sixteen hundred feet deep, sends forth gas at such a vehement pressure that a plummet-line weighing sixteen hundred pounds can be pulled out of the bore-hole by hand. The ascending speed of the gas is seventeen hundred feet per second; the quantity amounts to one million cubic feet per hour, or more than fourteen hundred tons a day; and the heating power is twenty five per cent. greater than that of good bituminous coal. After this explanation it is easy to understand that the well, situated in a valley surrounded by mountains, furnishes heat and light to the whole neighborhood. From one of its pipes, three inches in diameter, a flame rushes, "the noise of which shakes the hills, and is heard at a distance of fifteen miles. For a distance of fifty feet around the earth is burnt; but, further off, the vegetation is tropical, and enjoys a perpetual summer."



COMPOUND ENGINE WITH ROPE DRIVING GEAR. BY BENJAMIN GOODFELLOW, ENGINEER.

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ROPE DRIVING IN COTTON MILLS.

WE give an engraving of a pair of horizontal compound condensing engines, recently erected by Messrs. Goodfellow, of Hyde, at a cotton mill at Hyde Junction, near Manchester, England. As will be seen from the engravings, the power of these engines is transmitted from the flywheel to two grooved pulleys by means of round ropes. This system of driving is meeting with considerable favor in some districts, and it undoubtedly possesses several important advantages, especially in cases such as the one we now refer to, in which the speed of the driven shaft is required to be rapid.

The engines are of a well-known compound type, having a high-pressure cylinder 16½ in. in diameter and a low-pressure cylinder 33 in. in diameter, the stroke in each case being 4 ft. 6 in., and the pistons driving cranks at right angles to each other. The air pump is worked in the usual manner by means of levers attached by short links to the crosshead pin of the low-pressure engine. The engines are worked with steam at a boiler pressure of 80 lbs. per square inch.

The general arrangement of the engines, with a clear and well-lighted passage way all round about the foundations, is simple and roomy. The driving drum is the flywheel, and being constructed with V grooves to receive twelve ropes, each 6 in. in circumference, it is necessarily rather wide. Extra room is thus taken up by the engines as a whole, but there is an advantage in this, so far as the air-pump and condenser arrangement is allowed to share in the general freedom; for instead of these portions of the engine being buried in darkness and dirt, as they usually are, we find them in this instance clean, dry, and pleasantly accessible.

In cotton mills it is essential that the turning of the shafting shall be as even and smooth as it is possible to be, in order to obtain the best results from the spinning machinery. The steadier the turning, the greater may be the speed of the spindles, and when this is a matter of thousands of revolutions per minute, and the perfection of the thread or yarn and the quantity produced depends on the regularity of the speed as well as upon the other perfections of the machinery suited for the high speed, then the importance of steady communication of motion must be evident. In the case under notice the engines run at 50 revolutions per minute, while the spindles run at about 5,000.

The flywheel or drum is 22 ft. in diameter and runs with a circumferential speed of about 3,450 ft. per minute. In addition to the weight of the revolving flywheel or drum, which is of course the main item in this part of the matter, there is some advantage derived from the moving of the eleven ropes traveling at the speed as the periphery of the flywheel, and also from the revolutions of the two driven pulleys, which are small flywheels themselves. The actual result is that the motion of the ropes is exceedingly steady. There is an entire absence of all that vibratory movement so often seen in belts and bands in the various rooms of cotton mills driven by engines afflicted with irregularity of engine speed resulting from imperfect valve arrangements, or from light flywheels, which clearly proves that in this case these evils are avoided.

The exact form of the groove is shown in the detail view, Fig. 3, on our two-page engraving, this view being drawn one-third full size. The width of the groove at the entrance is $2\frac{1}{16}$ in., and the total depth 3¼ in., while the radius of the bottom curve is ½ in., and the angle formed by the two sides is about 49°. The rope rests upon the two inclined sides, as shown, and does not, when pressed by its full duty somewhat out of its original cylindrical form, reach the bottom of the groove. In the case before us, the power of the engines developed at full work is about 300 indicated horse power, which equals, say, 27 indicated horse power per rope. The speed of the ropes being, as already stated, about 3,450 ft. per minute, shows that the pull on each rope is about 258 lbs., or a very moderate strain for a 6 in. circumference hemp rope such as is used, and under these speeds and strains the ropes appear to wear, showing no signs of distress at the time of our visit, when they had been running for some ten or eleven months.

Before the use of ropes for this mill was determined upon, a calculation was prepared for driving by leather belts instead, but the estimated price of the belts themselves was so great (viz., $1,620) that the idea of their use was abandoned in favor of the ropes, the total cost of which was only $365. The simplicity of this method of driving, as compared with any arrangement of wheel gearing and intermediate shafting for carrying it, is very evident, and the quietude of the engine-room is such as can only exist in the absence of wheel gearing.—*Engineering.*

THE SIZING OF COTTON GOODS.*

By W. THOMPSON, F.R.S.E., F.C.S.

THIS subject is one which, since the commencement of the manufacture of cotton cloth in Lancashire and other places, has much engaged the attention of all manufacturers.

Much time and ingenuity has been, from time to time, spent in the invention and improvement of machinery required for the different processes employed in the production of cotton cloth, and the progress made in this direction has been enormous and brilliant, nor can anything be said against the machinery devised for what is termed sizing the yarn—yet, altogether, this operation, as it now stands, is one of the clumsiest, most unscientific, and least understood, with which the manufacturer has to deal.

That I may be clearly understood, it will be necessary for me occasionally to introduce other things connected with the manufacture of cloth, but which are not intimately associated with the operations of sizing, and which would be quite superfluous to those who have any knowledge whatever of the subject.

If we examine a piece of ordinary cotton cloth, we observe that it is composed of two sets of fibers running at right angles to each other. The one set, which runs along the piece of cloth, is called the "warp," or woof; the other set, which runs across the piece, is called the "weft." And, as a rule, if the fabric be more closely examined, it will be observed that the warp is the thicker and stronger of the two sets of threads. But, whatever differences may be observed, one thing is certain—that the warp has to withstand a much greater amount of strain, and wear and tear, in the process of weaving than the weft, and, consequently, the limit of strength required by the warp is much greater than that required by the weft. I have here an arrangement which I hope will serve to show distinctly

* Read before the Society of Arts.

THE PROCESS BY WHICH THE WARP AND WEFT ARE WOVEN INTO CLOTH.

The warp is received by the weaver wound on to a large roller called a beam; this is placed at the back of the loom so that it may revolve, to gradually unwind the warp as it is required. The beam contains as many ends or distinct threads as are required to form the entire breath of the cloth. These threads are taken and passed through what is called "healds." Healds are formed of a series of cotton or woolen threads arranged by stretching each between two long rods; each thread is provided with a loop in the center, and each loop is varnished to render it smooth, and thus protect it as far as possible from injuring the threads of the warp on the one hand, and as a protection against the wearing action of the warp on the loop, on the other. Four sets of healds are required for each loom; they are arranged the one behind the other, and each alternate thread of warp is passed through a loop in the first, and one in the third set of healds, and the remaining alternate threads are passed through the loops in the second and fourth set. The first and third set have an upward motion, whilst the second and fourth set have a simultaneous downward motion, which is communicated to them by an arrangement of machinery called treadles. The warp threads, after passing through the healds, are then passed through an arrangement called the reeds; this is of the same construction as the healds with the exception that each fiber extending between the two rods is formed of thin flat steel ribs, the two rods being not more than about 3 inches apart, and resemble a comb, the teeth of which are fixed at each side by two long rods; generally two threads of warp are passed between each two teeth or dents of the reeds, and passing over a fixed frame, are attached to another beam or roller in front of the loom, which has a revolving motion in unison with the rest of the machinery, and on which the cloth as it is produced is wrapped. The reeds, or long comb, are fixed in a wooden frame called the sleigh, which has a motion like a pendulum, thus communicating to the reeds the same motion which the pendulum gives to the bob; the reeds thus move to and fro in a direction parallel with the warps. On the sleigh, immediately underneath the reeds, is fixed a piece of wood, slanting from above downwards to the bottom part of the reeds. Another appliance finishes the description of the loom, and that is the arrangement for introducing the weft or cross-threads of the cloth. A rod of wood about one inch in diameter and 18 inches long, called the "picking stick," has attached to one end a strap, to which is fixed a small arrangement made of raw buffalo hide, which has previously been soaked in linseed oil to give it greater tenacity; the other end of the picking stick is attached by a hinge, and a rapid jerking horizontal motion is communicated to the picking stick. One picker is arranged at each side of the loom, and the piece of buffalo hide is made to strike violently against a small oblong box fixed to the side of the loom, with a hole through the end, through which projects the point of the shuttle when at rest. When the loom is started, the two sets of healds rise at the same time, as the other two sets descend, carrying with them the alternate threads of the warp, thus forming what is termed the "shed," which resembles the letter V, the apex of which is at the point in front of where the shuttle works, the other two ends of the "V" being formed by the healds carrying with them the alternate threads. The shuttle is made from a piece of boxwood tapered at both ends, about 1½ inches in diameter at its center and thickest part, and about 10 inches long, tipped with steel. Out of this wood is cut an oblong hole, in which the "cop" is fixed upon a steel pin. The cop is a bobbin of weft, very carefully and ingeniously wrapped, the end of which passes through a small hole in the shuttle, so that by pulling this end the thread unwraps from the cop with the greatest facility; the shuttle thus charged is placed in its box, and at the moment the shed is formed in the warps by the movement of the healds, the sleigh moves backward, so that the projecting piece of wood in front of the reeds is in an exact line with the two boxes on each side of the loom arranged to receive the shuttle, and the lower line of warps at this point is resting over the projecting wood. At this moment the picker strikes the shuttle violently at one side, and makes it shoot along the sleigh, over the lower line of warp threads, leaving a line of yarn behind it, and into the fixed box at the other side; the forward motion of the sleigh or pendulum presses up this thread of weft, then moves or falls backwards until it hangs perpendicular, and then the healds, by reversing their up-and-down motion, reverse the lines of the warp threads, making the upper line of the V, or shed, form the lower line. At this point, the picking stick again strikes the shuttle, and shoots it violently across the line of threads resting on the sleigh into the box from which it started; the sleigh, carrying with it the reeds, again moves forward, thus pressing each thread of weft up into the cloth thus formed; the weft at one side of the loom comes in contact with and supports a delicate arrangement called the fork, so that if the weft breaks the fork falls, thus bringing into action a series of levers which at once stop the loom.

So quickly do these machines or looms work that at an ordinary speed the shuttle is struck by the picker 180 times per minute, thus 180 threads of weft are woven with the warp in that space of time, and as each inch of an ordinary cloth or gray shirting contains about 64 threads, or picks, about three inches of cloth are produced per minute by each loom; but some looms are worked at even a greater speed than this, namely, giving about 220 threads, or picks, per minute, and thus producing in that time, from the above calculation, about three and a half inches of cloth per minute.

UTILITY OF SIZING PROCESS.

It will now be observed that the wear and tear on the warp by the pulling action of the healds, etc., is very great, and the process which was first introduced with the view of increasing the strength of the warp was called sizing.

The sizing process which was at first employed was simply to pass the threads of the warp through some adhesive matter, such as flour paste, and drying it; this gave the extra strength required for the warp to pass it through the loom, but it made the cloth produced feel harsh. Tallow or oil was then boiled with the flour or starch paste to give it the desired softness, and this mixture gives all that could be desired for the absolute manufacture of the fabric; but here the progress in sizing did not end. It was observed that different modes of mixing and applying size to the threads of the warp gave to them properties which, when woven into cloth, made the fabric appear fuller and better; and so well can this process be now applied that "connoisseurs"—and there are many in Lancashire who profess, and no doubt with much reason, that they can tell how much cotton a cloth contains by simply feeling it—are often deceived by the arts of an expert warp sizer; but these gentlemen seldom think so, and so there is yet ample scope for the ingenuity of the sizer. The problems then which the manufacturer of the present day must solve are rather complicated.

First, he must arrange to produce pieces of gray cloth of a certain number of yards in length and a certain number of inches in breadth.

Second, that piece of cloth must weigh a certain number of pounds.

Third, together with the first two qualities, it must possess an appearance equal to some standard, *i.e.*, must be made so that a "connoisseur" shall be able to say, "This piece is equal to the sample required, it has the proper feel, and it contains the proper number of threads of warp and weft to the quarter inch;" this last-named test is generally made by means of a small brass arrangement with a lens which folds into three parts, and when opened for use has the appearance of three sides of a box; one side serves as a stand, this has a square or round hole cut in the center, which is exactly a quarter of an inch in diameter; the second side acts as a pillar to support the third, in which an ordinary glass lens is set opposite to the hole in the lower side. This arrangement is put on any piece of cloth to be tested, and the connoisseur looks through the lens, which magnifies the threads, and so enables him to count the number present in every quarter of an inch of cloth, and he is at once able to tell you how many "picks" or threads of warp and weft the cloth contains to the quarter inch. They say that this is 15-16, and that is 20-24 cloth, meaning that it contains 15 threads of warp and 16 of weft in the one piece, and 20 threads of warp and 24 of weft in the other. And I dare say that in Manchester this glass is as common a pocket companion as penknives are in other towns, where the pockets of the inhabitants are not filled by the looms of the weavers. The last and most important object of the bulk of Lancashire manufacturers is to make gray cloths of specified dimensions, weight, and appearance with as little cotton as possible, the remainder of the weight, "feel," and general appearance to be made up with size.

I cannot give you any idea of all the different mixtures which are used to produce "size"—their name is legion—but I will endeavor to place before you the different substances generally used, of which two, three, four, or more, are mixed, and boiled with water to produce what is termed size.

SIZING MIXTURES.

There are five different classes of substances used, viz:

1. *For giving Adhesive Properties to the Size.*

Wheaten flours of different kinds.	Farina.
Sago.	Rice.
Indian corn starch.	Dextrine or British gum.

2. *Materials used to give Weight and Body to the Yarn.*

China clay.	Sulphate of soda.
Sulphate of baryta.	Silicate of magnesia (soapstone).
Do. lime.	Silicate of soda.
Do. magnesia.	

3. *Oily or Greasy Matters used for "softening" the Size or Yarn.*

Tallow of different kinds.	Olive and other oils.
Bleached palm oil.	Paraffin wax.
Cocoa-nut oil.	Bees'-wax composition.
Castor oil.	

4. *Other Substances used for Softening and giving Weight and Body to the Size and Yarn.*

Chloride of magnesium.	Soap.
Chloride of calcium.	Grape sugar.
Glycerine.	

5. *For Preserving the "Size" from Mildew and Decomposition.*

Chloride of zinc.	Cresylic acid.
Carbolic acid.	Salts of arsenic, etc.

In the first-mentioned class of materials, the most commonly used substance is Egyptian flour, because, as a rule, that is the cheapest flour which can be purchased; but in selecting a substance from the first, or "adhesive" class, the manufacturer ought to take into consideration the purpose for which it is required. If he intends to manufacture cloths for what is called the home trade, most of which are sold direct to the bleacher or calico printer, then size is required which will give strength to the warp without giving it much weight, because a bleacher always finds how much size a cloth contains, and therefore his balance and weights are sure to keep an accurate account with the manufacturer, because, if he buys a lot of pieces of cloth each weighing 8¼ lbs., which is a common standard of weight, and finds after he has washed and bleached them that each weighs only 5 or 6 lbs., he knows there is something wrong, not only in having bought 2 or 3 lbs. of size instead of cotton in each piece, but that the extra work and material required to separate that stuff from the cotton has made the small amount of cotton which he has left additionally expensive.

TESTS FOR MIXTURES.

There are great differences in the properties of the different starchy matters, and also to some extent in those of the same kind grown in different places. These differences may, perhaps, be seen simply by boiling with water one part by weight of each sample with ten times its weight of water, observing the consistency of the resulting paste when boiled for three minutes, and then pouring it into a small cup, allowing it to stand for some hours to cool and set, and then examining the moulds thus produced; by tilting them from the cups into the hands, and pressing them with the fingers, note can be taken of their firmness or softness to the touch, their brittleness, elasticity, adhesiveness, etc.

Another test may be made, by boiling 1 part of each, flour or starch, with 40 parts of water, and then allowing the samples to cool to a fixed temperature, say 100° or 60° Fah.; and then, by means of a hydrometer, taking the densities or specific gravities of the resulting solutions.

By these tests, it would be observed that farina, or potato starch, becomes, by boiling, very much thicker than any of the others; that sago stands next in this respect; that maize, or Indian corn, starch and rice flour, follow in order, and produce the thinnest or least dense solution. But with respect to the moulds or shapes produced by the two last mentioned, rice is short and brittle, and flour has a much more tenacious character.

If, then, it be desired, to put as little size on the threads of the warp as possible, a composition should be made by using farina as an adhesive, because a much smaller proportion of this ingredient will produce a size having the required "consistency" or "body," and the threads can therefore only absorb a proportion of it.

If, again, it be desired to put a large amount of size on the yarn, then wheaten flour is best adapted for this purpose, because an equal weight of it will boil to a much thinner liquid, and therefore the warp or yarn will be able to absorb much larger proportions. For the same reason, if it be desired to introduce a material giving greater weight, such as china clay, then wheaten flour is best adapted for fixing it to the thread; and where a specially large proportion of clay is required to be fixed in the fabric, English wheaten flour is better adapted for the purpose than Egyptian flour, because it contains a much larger proportion of gluten, and that ingredient has strong adhesive properties. The starchy matter which has, perhaps, least adhesive properties is rice, and this ingredient is often used to adulterate wheaten starch, and this is one of the many causes of annoyance to which the sizer or manufacturer is subjected. Having bought flour, with which he mixes china clay and other ingredients in certain proportions, he finds that he is able to produce a size which gives him all he requires, viz., the desired weight of size which sticks well on the yarn, and appears to the uninitiated as if the cloth made from it were quite free from any sophistication; but, unfortunately for the manufacturer, his supply of flour becomes exhausted, and he is forced to purchase more, and possibly he buys not pure flour, but flour adulterated with finely ground rice, he uses this mixture for his size, and the result is, to express it in his own words, he "gets wrong;" when the warp is undergoing the process of weaving, the china clay, not being fixed firmly by the adulterated flour, flies off, forming a cloud of dust in the weaving shed, and when the cloth is produced, it is found not to be sufficiently heavy, and not only so, but the uninitiated would be very apt to say that the fabric had been much sophisticated, because when shaken, the sophistication would reveal its presence by coming out in a shower of dust. It is important, then, that the manufacturerer should test each sample of flour which he buys, that he may be certain that he does not get an adulterated article.

The microscope does valuable service so far as this is concerned, but, before applying it, the flour must be treated by a preliminary process. Flour is composed principally of two different materials, the one named gluten, the other starch; and before examining for adulteration with other starches, the former must be separated from the latter; this is done by mixing some of the flour with water, and making it into dough, which is then thrown on to a piece of silk cloth, of the same kind as that used for dressing flour, the sides of which are taken up and tied so as to form a loose bag round the dough; this should then be alternately dipped into a basin of clean water and pressed with the fingers, the starch will pass through the silken cloth into the water, making it milky, whilst the gluten remains behind as a soft caoutchouc-looking mass; but I should say that it has only this exact appearance when the flour is what a bread baker would term of fair or good quality. The starch, which will settle to the bottom of the water, should then be examined by the microscope, which will reveal the presence of adulteration with other starch by the form of the granula. Great differences exist in the appearance of the gluten obtained from different samples of flour, and the observation of these differences teaches us a great deal relative to the kind and quality of the sample. English wheaten flour usually leaves a full homogeneous gluten, which adheres in one piece, and may be drawn out into long fibers without breaking. Again, we find other flours of the same kind, which have been damaged by moisture or other cause, leave about the same amount of gluten, but its physical properties are quite different; it has lost much of its plastic nature, and, if you attempt to stretch it, it breaks easily.

We thus descend the scale, both as regards quality and quantity of gluten present in flour, till we arrive at Egyptian flour, where we find very little gluten, of very bad quality; in some cases so bad as to be almost devoid of plastic properties, so that it remains in the silk in small pieces which will not adhere to each other.

PROPORTIONS OF SIZING.

It is evident, then, that when the manufacturer desires to fix in his fiber a large proportion of mineral matter—such as china clay—he ought to use flour containing a large percentage of gluten; and this is an important point, because some manufacturers will take you into their confidence and tell you that they have lately risen to such a state of perfection that they can put over 100 per cent. of size into their warp, *i.e.*, that they take 1 lb. weight of yarn, and after passing it through their sizing machine and drying, it will weigh 2 lbs.; and yet the men who carry on the manufacture are, as a rule, honest. They do not hide from the purchaser the fact that their goods contain a large quantity of size, and the merchant who buys them does so quite cognizant of the fact. When the cloth suits his requirements, and he desires to ship them to some foreign country, he has but one more question to ask, and that is—Is your size good? Is there no fear of mildew? And these being answered to his satisfaction, a business transaction takes place.

To show still further that sizing is not altogether dishonest, I think I can give no more forcible idea than by saying that often more than the whole margin of the manufacturer's profit lies within the size used. Still the subject will remain a mystery to many. Why put size in cloth to sell at a less price than that for which the cloth can be produced from pure cotton? The question is not without defence. The manufacturer will tell you openly that he will be very glad to dispense with heavy sizing, but the merchant says, "I wish to buy from you cloth which contains a large quantity of size," and so the manufacturer has no other alternative than to supply his customer with his wants or give up business. We have thrown the onus of this apparently dishonest dealing on the head of the merchant, and we must now go a step further to hear what he has to say for himself. He will tell you that the natives of the countries to which he ships those goods make various pieces of clothing out of them, and they prefer to buy a cloth at a given price which has a full and good appearance (effects produced by judicious sizing) to paying the same amount for a cloth which is entirely composed of pure cotton, but through which the daylight would penetrate, and show every thread of the fabric; in fact, they have no objection to clothe themselves with a composition of flour, tallow, and china clay, to which a little cotton has been added to make it stick together. I am informed that, as a rule, they do not wash the cloth before wearing it, so that, if some enterprising Lancashire manufacturer could hit upon the mode of making cloth without containing cotton at all, but composed entirely of size, he would, no doubt, be considered a benefactor by his poorer foreign brethren; but although many manufacturers have approached very closely to this acme of perfection, I have not heard of any whose genius has carried them to the desired end. As much has been said and written against manufacturers for what appears to be their dishonest practices, I will venture to say something more in their justification by taking a parallel case. Some years ago, we heard a great deal about adulterated paper, and one Scotch chemist distinguished himself by pointing out the frauds which paper manufacturers began to practice, viz., of introducing plaster of Paris and other mineral substances into writing and other kinds of paper; the public then looked with indignation on the perpetrators of such frauds, and the representatives of Her Majesty's Government, in giving their orders to paper manufacturers, always stipulated that the paper should be pure, *i.e.*, made from pure vegetable pulp, and free from adulteration. Persons who had to use many of the cheaper varieties of this "pure" paper found it to be the most objectionable stuff, the pen penetrating it with the greatest facility, and the writing showing as well on the one side as the other. *Experimenta docent.* Probably many present have had the honor and annoyance of writing on pure paper, in the shape of post-office newspaper wrappers, which were supplied some years ago. Paper manufacturers afterwards showed excellent paper, which could be produced at the same price as the objectionable stuff referred to, but, alas! it was impure. It contained about half its weight of plaster of Paris; but, no matter, it dawned upon the public generally that if good and easy writing could be made upon a sheet of plaster of Paris, it was all that they could desire. We heard nothing more of the frauds of paper manufacturers, and now there is no paper mill in the United Kingdom, of any size, which cannot consume and convert into paper with facility, in the space of six days, quantities of sulphate of lime or plaster of Paris, and china clay, varying from one to ten tons. And if we take almost any of the paper we now use, and burn it, we find we have left as an ash a complete sheet of clay or other mineral constituent, which had originally been mixed with the vegetable pulp used to give it body or consistency; and we have now, in this respect, got so far over our prejudices that we are content to read the news of the day which has been printed virtually upon sheets of china clay or plaster of Paris.

The end justifying the means, we are a clean people, and we wash our linen before we wear it; we object to wear garments half of which are composed of china, clay, flour, and tallow, or other things, and our manufacturers are quite pleased to supply us with pure cloth. The lower classes of India and other foreign countries prefer to wear china clay and tallow as well as cotton, and our generous manufacturers are pleased to comply with their demands. A short time ago, an illustrious Lancashire divine, ever ready with his pen and tongue to correct the faults and sins of his people, attacked our unfortunate gray cloth manufacturers, and denounced their practice of sizing as against all the laws of the Bible; but from observation I have come to the conclusion that even that gentleman prefers to wear starched linen to the pure fabric, and sometimes, therefore, prefers precept to example.

USE OF FLOUR IN SIZE.

When the manufacturer uses wheaten flour in his size, he generally submits it to a peculiar preliminary operation; he throws a large quantity, generally several tons, of flour into a large cistern, adds to it about ten times its weight of water, thoroughly mixes the two together by means of revolving arms worked by machinery, and allows the whole then to remain at rest to ferment. This fermentation is produced by the unfolding or decomposing action of a ferment or living cell, exactly in the same way that the starchy matters of malt are converted into alcohol by the action of another species of living cell, called yeast in the process of brewing, or of whiskey manufacture in the hands of the distiller. The difference between the method pursued by the brewer or distiller on the one hand, and the gray cloth manufacturer on the other, in producing their different fermentations, is that the former two clearly understand that they must add yeast to their worts to produce the fermentation, and having studied the exact action of their yeast, they know the exact point at which to stop their fermentation to obtain the best results. The manufacturer, as a rule, is entirely ignorant of the fact that the fermentation of his flour is caused by a living cell at all, and I think that very few have any clear idea of what they are supposed to gain by the operation, the principle for the process being that their fathers did it before them, and they follow in their footsteps. I do not say that the process is an absurd one; on the contrary, I believe it is of much value, although I think it has been arrived at by a series of blunderings. One thing is certain, that much might be gained to the user of the size by a careful study on his part of this operation. My opinion is that they inoculate their flour with a certain living germ, which decomposes the gluten and other nitrogenous bodies in the flour, thus preventing the remaining starchy matters from being so subject to mildew, for the same reason that we inoculate ourselves with vaccine lymph to destroy certain pabula in our blood, which, if they remained intact, would be liable to be attacked by the germs of smallpox, which would do much greater ravage to the human body than the comparatively innocuous cells of the vaccine lymph. After the sizer has run or pumped off one batch of fermented flour, he leaves some at the bottom of the vat, which contains numberless cells of the desired ferment. Fresh supplies of water and flour are added to this, the mixture well stirred, the little leaven left at the bottom of the vessel leaveneth the whole, and the fermentation is allowed to proceed for one, two, three, or more weeks, according to the whim or fancy of the manufacturer. During this time, the gluten is decomposed and dissolved in the fluid, which soon becomes more and more acid from the production of lactic, acetic, and other acids, and a copious effervescence takes place from liberation of carbonic dioxide. A certain larger or smaller quantity of starch is undoubtedly decomposed and destroyed, and the question which I believe as yet remains to be solved is—When has this fermentation proceeded sufficiently far to obtain the maximum amount of benefit from the operation? because more harm than good is often the result of prolonged fermentation. A peculiar and interesting variation in the process takes place, which I should think was interesting to an outsider, and that is that occasionally the sizer finds that he "gets wrong" in his fermentation, and instead of the not unpleasant odor which the "healthy" fermentation produces, he may have a putrid fermentation taking place, when the smell emitted is almost unbearable, and, as a rule, the manufacturers have no idea as to how this has been caused. One thing is certain, that the flour which produces that result is condemned, although the flour may or may not have been its cause. The fact is, that some germs other than proper ones have got into the flour—probably the putrefactive vibrio—and it is qaite certain that, unless that germ be destroyed or eliminated, each batch of flour will undergo the same abnormal fermentation. What ought, therefore, to be done when such takes place is to clean out the cistern and boil water in it, which, as a rule, will have the effect of destroying or rendering inactive for a time the foreign or unhealthy germs or ferment, and so allow again the "healthy" fermentation, which should be produced by adding to the flour a quantity of another sample undergoing a healthy fermentation.

When the flour has undergone this first process, it is treated in a variety of different ways by different manufacturers; some at once, without any further operations, employ it for the manufacture of their size, some only run off the supernatant acid liquor, others mix it with clean water, allow the starchy matters to subside, and run off the supernatant clear liquor, and others again wash the starch still further with water. The starchy matter in one of these conditions is transferred to another cistern, heated to about 100° F., and water is added to it, if necessary, to bring the milky mixture to a certain specific gravity (sp. gr. 1·09 to 1·12), the density being taken at that temperature, generally from 18° to 24° F. Then it is mixed with the other ingredients of the size, standing about the same specific gravity, and a sufficient quantity of some blue coloring matter is added to destroy the yellowish or brownish appearance of the size, and make it look whiter. (This yellowish or brownish shade seems to be deepened in the starchy matter during the fermentation.) This total mixture is then thoroughly boiled by steam, during which the size is kept stirred by means of wooden arms kept revolving by machinery, and is, lastly, pumped to the sizing machines, where it is applied to the warp threads.

WEIGHTING MATERIALS.

The next class of materials with which I propose to deal are those which are added to the size to give simply body or weight to the yarn. The substance almost exclusively used for this purpose at the present time is china clay, and it is not absolutely necessary that this material should be of the finest quality. It is largely manufactured in Devon and Cornwall, from the large disintegrating beds of felspar which are found there. This felspathic rock, when dug out from a considerable depth below the surface of the ground, is very hard, and contains, besides clay, silica or sand, mica, potash, silicate, and other impurities, and it is necessary to separate these ingredients from the clay before it can be used in the process of sizing. The place of manufacture is always situated by the side of a stream. A series of vats are prepared, the top of the second vat being placed in a line with the bottom of the first, the top of the third being placed in a line with the bottom of the second, and so on with each succeeding vat.

The rock is allowed to weather, and by the action of the rain, frost, and air, it gradually crumbles down to a soft friable mass; this substance is passed through a mill, by which it is reduced to a powder of a certain degree of fineness; this powder is then thrown into the first vat, water is added to it, and the whole well stirred up; the lighter particles by this means are kept in suspension in the water, whilst the heavy particles never rise from the bottom of the tank; the water holding the clay or lighter particles in suspension is then allowed to run over into the second tank, where a large portion of the suspended clay settles; it continues to flow into the third, fourth, and fifth tank, depositing in each a large proportion of the suspended matter, till it becomes evident that the finer particles will be carried furthest by the water. It is equally evident, therefore, that what are termed the "finest qualities of clay" will be deposited in the tanks furthest from the one in which the raw material is placed. When this operation has been continued for some time in one set of tanks, it is stopped, and all the water allowed to run away, when there remains in each a soft mud, which is

CHINA CLAY.

This mud is taken out from the different tanks, and allowed to dry to the consistency of a firm dough. This is cut into brick forms, which are afterwards laid on the top of each other till they have thoroughly dried, when they are ready for the market. It becomes, then, important that the cloth manufacturer should select china clay which is absolutely free from gritty matters, and which, when mixed with water on a smooth plate or piece of glass, and rubbed by the finger, goes into a smooth, soft, creamy-looking mixture. Another good test for the quality of china clay is to place a little of the material between the teeth and chew it; if the slightest grittiness can be felt, the stuff should at once be rejected, but if it behaves well under those tests, and its color be white and good, it may safely be employed for sizing purposes. China clay is a chemical compound of silica and alumina, although, unlike most other chemical compounds, these two bodies do not exist in any definite proportions. It may, however, be taken as a rule that as the percentage of alumina in clays increases, the soft or oily feel increases in proportion. The following analysis gives the proportions of the different ingredients contained in china clay of average quality used by manufacturers, taken from a large number of analyses made by myself:

	Per cent.
Silica	46·47
Alumina	40·03
Oxide of iron	0·38
Lime	trace
Magnesia	trace
Potash and soda salts	1·24
Water, organic matter, etc	11·88
	100·00

The reasons which make it necessary to use substances in sizing which are absolutely free from grit are obvious on looking to the arrangements of the loom. Each thread of the warp passes through a small loop in each thread of the healds, and it is evident that a considerable amount of attrition must take place between the warp threads and the sides of the loops through which it passes, as the healds are moved alternately up and down. If, then, the warp threads have attached to them anything of a gritty nature, the healds are very quickly cut through; but here the evil does not end, because it is a most important matter that each loom should produce its proper quantity of cloth, and those mills make the most profit where the speed of the machinery is quickest. If, then, anything interferes with the easy and constant working of the looms, the manufacturer says his "average," meaning his average production of cloth per loom, decreases accordingly. When one of the loops of a heald break, at that moment the girl who has the loom under her charge must stop it, and have the loop repaired before the machine can be again set to work. And not only is this filing action exerted on the heald, but it is exerted with equally injurious effect upon the reeds, and, in a comparatively short time, the thread will file its way through the steel teeth of the reeds, which keep moving in a direction parallel with the warps. Further, when this action has damaged the steel

teeth by filing a notch in each, that notch reacts on the threads of the warp and cuts them, so that the loom must again be stopped till each breakage be repaired. And thus, when china clay is not carefully selected, the cloth producer suffers severely, not only in damage to plant, but in having a small "average" production of cloth, which is most probably full of flaws.

The treatment of clay required for the manufacture of size has some interesting points about it. It is boiled with water and other ingredients before it is added to the flour. I use the words "other ingredients" advisedly, because it is practically almost impossible to boil china clay alone with water; if this be attempted, the clay will settle to the bottom of the vessel, and as each bubble of steam is generated would shoot the clay out in all directions; but if soap, tallow, caustic soda, or some other substance, be dropped into the boiler, the spirting of the white mud will at once cease, and the liquid will then boil quietly and evenly for any length of time.

SUBSTITUTES FOR CHINA CLAY.

The other ingredients which may be and have been used for the same purpose as china clay, and which I have mentioned under the class "body and weight" giving materials, are now seldom employed. Steatite, *alias* soapstone, or silicate of magnesia, stands next to china clay as a substitute, but, as it is more expensive, it cannot well compete with china clay.

Sulphate of baryta, heavy spar, is of a gritty nature, and can never be reduced to a soft, oily-feeling powder, and although it is an excellent substance for giving weight to the yarn, its destructive effects on the healds and reeds, and the consequent loss in production of cloth, is very great. Silicate of soda, or soluble glass, was at one time tried, and promised to be a valuable constituent of size, but it was soon found that it crystallized upon the warps, causing all the numberless evils of which I have already spoken, the *bête noir* of the manufacturer. Sulphates of soda and magnesia are not often employed in warp sizing, as this *bête noir* shows itself.

With the view of softening the yarn, to allow it to weave more easily and nicely, one or more members of a class of bodies, which I have termed

"SOFTENINGS,"

are employed. Tallow is in most general use. The caution required in selecting this substance is perhaps less than that required for any of the other constituents, because it varies less in quality, and cannot well do much harm to the size, if used in proper proportions, and with proper precautions. It should, however, be as free from color and rancidity as possible, and its melting point should not be too high, otherwise its "softening" properties will not be so great. It is important that this should be attended to, because if a size possesses all the desired properties when certain ingredients are employed, the sizer should be careful, when it is necessary for him to buy other supplies of these ingredients, to see that the quality of each is precisely the same as that which he formerly employed. To take the melting-point of tallow accurately, the following method should be adopted: A piece of glass tubing with one-eighth inch bore should be selected, heated to redness before the blow-pipe, or in the ordinary flame of a Bunsen burner, and then drawn out to form a capillary tube, having a bore about sufficient to allow an ordinary sized pin to be passed into it. A small amount of the tallow to be tested should be melted in a cup or other vessel, and any sediment which it contains allowed to settle. The surface of the melted tallow should then be touched by one end of the capillary tube, which should be two or three inches in length, when a small column of about one-eighth or one-sixteenth of an inch of the melted tallow will run into it. The tube should then be withdrawn, and the tallow allowed to cool during five or six hours. This capillary tube is then fixed to a delicate thermometer by means of a small india rubber band, so that the end containing the tallow may be in contact with the mercurial bulb of the thermometer; these are immersed for about 1½ or 2 inches in water contained in a glass beaker; the plug of solid tallow in the capillary tube prevents the water from rising into it. The beaker is gently heated by a small gas flame till the tallow melts, when it will at once rise in the capillary tube, by the pressure of the water, to the surface. At this point the temperature is noted, and taken as the "melting-point" of the tallow. A simpler but rougher mode may be adopted by cutting a piece of the tallow about the size of half a pea, throwing it on to the surface of some water contained in a vessel, and gradually heating the water, at the same time stirring it gently with a thermometer, carefully watching the pellet of tallow as it floats. As soon as it begins to melt, which is shown by a rapid flow of oily matter from all round the pellet on to the surrounding surface of water, the temperature indicated by the thermometer is noted, which gives roughly the melting-point of the tallow.

Some of the tallow should be placed in a test-tube, and gently heated till it melts. It may then be observed whether it contains foreign matters floating in it, or water which would settle to the bottom. Pure warm water should then be added to the tallow, shaken violently with it, and allowed to settle to the bottom in a warm place. The water should be drawn off by means of a pipette or glass tube drawn out at the end; blue litmus paper being dipped into it, the degree of redness given to the paper will give some indication of the degree of rancidity.

OILS FOR SOFTENING.

Besides tallow, oils of various kinds are employed for softening, and lately paraffin wax has been much used. The color of the body should be good, and it should not be too hard—*i.e.*, its melting point should not be too high. This substance, however, is most objectionable when the cloth is intended to be washed or bleached, as it is with difficulty separated from the fabric again; because, unlike tallow, and other animal and vegetable fats, it is not dissolved out by soda or soap, and is very apt to stain the goods. But it is still more objectionable when such goods are required for printing or dyeing, as the dye will be liable to adhere irregularly to such cloth. It is advisable, before employing any of these fatty matters, to melt and wash them with water, as they generally contain impurities which can be separated from them by this means. Many sizers employ soap along with the oily matters, to facilitate the formation of an emulsion, because the oily matters are apt to float on the surface of the size; in such cases, the soap and oily matter is boiled and mixed together in one boiler, and then transferred to another containing china clay and water; the three ingredients are then boiled together, and, lastly, mixed with the flour or starchy matter, to be again boiled with it for the formation of the size.

HEAVY SIZING.

Other bodies are now largely used for the purpose of softening the yarn, which have the further advantage over tallow of communicating increased strength to the yarn, as well as weight, and, as the yarn is not so likely to break, so increasing the average production per loom of the cloth. The ingredients most commonly employed—but especially by those who wish to size their yarn as heavily as possible—are chloride of magnesium and chloride of calcium. These bodies are known generally among manufacturers by the singular name of "antiseptic;" they possess little or no antiseptic properties, and in my opinion the word "septic" would be a much more appropriate term, as I hope afterwards to show. The valuable properties of these salts depend on the fact that they are exceedingly deliquescent; so that, if crystals, or pieces of these solid salts, be left exposed to the air, they will absorb moisture, and spontaneously go into solution. When, therefore, they are introduced into yarn, they keep it always damp, and thus greatly increases its strength, because water has that power to a marked degree; and from a few experiments which I made lately I have been led to the conclusion that if cotton thread be deprived especially of its natural moisture (*i.e.*, an amount of about 8 per cent., which is always found in cotton), its strength is very rapidly decreased in proportion. I tested this point by taking nine different leas of the same yarn. A lea is a small hank, produced by wrapping on a reel, having a circumference of 54 in. 80 threads of yarn; a lea, therefore, is 120 yards in length. These were accurately weighed separately, and each placed in a stoppered glass tube; three of them were afterwards put in a water-bottle to dry at 212° F., and then transferred dry again to stoppered test tubes; and three were placed over some water contained in a plate, which was gently heated, under a large glass bell jar, to allow them to absorb as much water as possible, and then placed in stoppered tubes as before; whilst the remaining three were left in the original test tubes, thus representing the yarn in its original condition. All these leas were then broken by means of the "strain" apparatus. This is an apparatus where a strong spring, fitted exactly like one used for weighing, is attached to a flat piece of wood which is laid in a horizontal position. About 2¼ ft. apart from this is fixed an arrangement in which slides a long flat piece of brass, with a rack on its upper side and a hook at the end. The hank is placed on between the two hooks of the balance at the one side, and the ratchet arrangement at the other. The wheel is worked, and as the pulling force becomes greater and greater, by the ratchet hook being worked along the slide, the spring is stretched out further and further. A small steel pin is fixed on the end of a spring, which passes down a line cut in the brass barrel or indicator, which covers the spring, and this pushes before it a small, loose iron pointer. At the moment the yarn breaks, the spring recoils violently, leaving the loose iron pointer at the furthest point to which the spring had been drawn out, and this, therefore, indicates at once the weight required to break the yarn. When the nine samples of yarn were broken, I weighed each, then dried them and weighed them again, and the following results were obtained as averages for each set of three leas:

Original weight of yarn. Grains.	Condition of same.	Percentage of moisture.	Breaking strain. lbs.
1° .. 33·21	unaltered	8·93	64
2° .... 33·33	moistened	17·39	69·2
3° .... 33·85	dried	2·89	39·9

These results then explain another *bête noir* of the manufacturer. In large mills hundreds of pounds per week are lost by what they call

EAST WINDS,

if they prevail during that time. I have made many inquiries as to this, and find that the words "east wind" are used rather vaguely. The fact is, that cold or frosty weather has a most injurious effect on the weaving, and I believe that the reason is this: a certain volume of air, say, at 70° Fah., always contain a much larger proportion of moisture than the same volume of air, say, 30° Fah. When each volume of air at these different temperatures is at or near its "saturating point," weaving sheds are generally kept about a constant temperature, between 60 and 70° Fah., and the result is that cold and therefore dry air enters them, and is heated up to, say, 65° Fah., when it at once begins to absorb moisture from everything which contains it, so as to saturate itself. It therefore evaporates not only the excess but the natural moisture contained in the warp and weft, and therefore weakens the threads so that they are not able to withstand the strain of weaving, and one breaks after another; the loom must be stopped to repair each breakage, and the result is, a small average production of cloth. The fact is well recognized that much better weaving and larger average productions of cloth are made in weaving sheds situated in a valley near a stream, where the air is always comparatively damp, than when the shed is situated in an open or elevated position.

To counteract the effects of cold weather, many manufacturers allow fine jets of steam to escape into their sheds, and this has the desired effect of making the weaving go well; but this plan has its disadvantages, because, as the work-people are paid by the number of pieces, they sometimes turn on too much steam, and do not regulate it properly, so that the yarn becomes damp, and great risk is then run, as the pieces of cloth are apt to mildew if no real antiseptic has been added in sufficient quantity to counteract this influence.

The chlorides of calcium and magnesium have the advantage of always producing good weaving and a good average production of cloth, although they have some, I should say, insuperable disadvantages when used alone, as I shall afterwards show. The next two bodies which are sometimes added to size, to produce softness and strength in the warps, are

GLYCERINE AND GRAPE SUGAR.

The former is in most general use: it is, however, much more expensive than the chlorides of calcium or magnesium, but it is not so apt to produce mildew. Excess of glycerine or grape sugar gives to the cloth a sticky "feel," whilst the chlorides of calcium and magnesium are put into the warps in such proportions in some cloths that they feel almost wet. As a matter of curiosity, I put a piece of cloth, having this "feel," under a glass bell jar, standing over a plate of water, and left it there for a few days at the ordinary temperatures of the atmosphere. I took it out, and, by simply wringing, I was enabled to express from it a considerable amount of liquid.

When chloride of calcium and magnesium are employed in size for the purposes of giving weight, softness, and strength, it is necessary, and especially where a large proportion of flour is used, to add to the size one of the substances mentioned under the class antiseptics; chloride of zinc is the one now most generally used, and there is no doubt that it is

A POWERFUL PREVENTIVE OF MILDEW.

From some experiments which I made with this substance, I found that, to gain its maximum effect, it was necessary to boil the chloride of zinc direct with the flour, and then to add the china clay and other ingredients; but if the antiseptic be boiled first with the clay, and then added to the starchy matter, as many sizers do, a large proportion of its effects are lost, and size thus prepared may mildew, whilst that produced by the first-mentioned method will not; the clay seems to have some effect in combining with or absorbing, but at all events in rendering partially inert the antiseptic effects of chloride of zinc, or when an insufficient quantity of chloride of zinc is employed in heavily sized goods, mildew and decomposition may result. Carbolic acid is a still stronger antiseptic than chloride of zinc, and I am surprised that it is seldom used for this purpose. The reason given by those who have tried it is that it produces a smell in the cloth, but my impression is that a sufficiently small proportion might be used to act sufficiently as a preventive of mildew, and yet be imperceptible to the smell. Compounds of arsenic and also mercury have been used, but both being very poisonous ingredients, they have fortunately never been employed to any extent, and it is unlikely that they ever will be.

Having described briefly the different materials used in sizing, I come to the actual process by which the size is communicated to the yarn. There are two processes in general use, the one is called "ball" or "tape sizing," the other "slashing."

TAPE SIZING.

In the former, the proper number of threads required to make sufficient breadth of cloth are put together so as to form a long rope, and that rope is coiled together to form a ball; a number of these balls of warp are placed in boxes and simultaneously passed through size kept boiling in a large trough, by taking the end of each rope, and passing it between two sets of pairs of rollers placed at the bottom of the trough to press the size into the threads, and, lastly, through a third pair of rollers after it leaves the size, to press the excess of liquid out; the warps are then passed, in the form of a very long piece of tape, into a room above, where it is dried by passing over a series of hollow cylinders, made of sheet iron, heated by steam, and is, lastly, again coiled into balls and sent back to the manufacturer, because the process of ball or tape sizing is generally carried on as a separate business; the warp threads are then opened out, and wound on to the beam, to be afterwards arranged in the loom for weaving.

The next general process is that of

"SLASHING,"

for the sake of giving greater regularity or evenness to the yarn when wrapped on the beam, which is an essential point. The yarn is wrapped from a number of different beams on one beam; thus, suppose it be intended to make a cloth having 2,000 threads of warp, the manufacturer takes, say, 10 different beams or rollers of the same size, each containing 200 threads of unsized yarn; the threads from each beam are all brought together and passed in a line, being kept separate by passing between guiding teeth, which project from a cross wooden beam; they are then passed between one or more pairs of rollers, depending upon the amount of size required to be introduced into the warp; the one-half of the under roller of each pair works in a box, like a cylinder cut longitudinally, which is kept nearly filled with size and heated by steam. By this means the under roller carries a layer of size on its surface, and presses it into the threads as they pass between it and the upper roller. It is lastly passed over, generally, three hollow cylinders, heated by steam, and in some places fans are kept working underneath, to aid the drying process. The threads, after being dried, are wound on to a beam, the same size as one of those which originally contained the tenth part of the threads, and this beam is placed at the back of the loom, to be woven with the weft. A beam generally contains about 800 yards of yarn, and will make about 20 pieces of cloth of about 37½ yards each. The healds will generally last, if the sizing be good, to make about five beams of yarn, and are thus capable of producing about 100 pieces of cloth, whilst the reed ought to stand, with repairing, for two or three years.

The warps on the beam are marked at equal distances required to produce certain lengths of pieces of cloth, generally about 37½ yards, and when the weaver arrives at the end of each piece, which is indicated by a daub of blue coloring matter, she puts in what is termed the heading. Each firm has its own "heading," and a manufacturer knows his own cloth by that means. A few inches of warp are left between each piece of cloth; however, when the beam is filled with cloth, each piece is unwrapped from it, and cut off, then it is folded backwards and forwards, by sticking a strong steel needle through one end of the piece, thus stretching it in the direction of its length to another strong needle, both of which stick out from a wooden beam supported from the ground, the distance between the two needles being about one yard; the cloth is doubled or folded on itself, and the ends of the double ply of cloth thus made is pushed on to the needle; the cloth is then stretched to the other needle, when it is again doubled, and the end of the fold pushed on to it, and thus fixed and returned to the second needle; thus the cloth is wrapped into plaits one yard in length; this is again folded into three parts, by laying the piece thus folded on a table, and folding one side on itself, and the other side on the top of it, thus leaving only one end of the piece visible, which has the "heading" woven into it. These pieces, thus arranged, are sold to the merchant or shipper, who puts on the back of them his trade marks, and then placing generally two lots of these pieces side by side, he packs them into bales ready for shipment. This is done by placing one-half of the necessary packing on the stage of a hydraulic press. This

PACKING

differs to a certain extent with different cloths and different packers, but the following may be taken as a type:—Two strong iron hoops are first placed on the stage; on the top of this is put a large coarse hemp wrapper, then a sheet of tarpaulin, or coarse hemp cloth, which has been covered with a mixture of Stockholm tar and pitch, then a sheet of fine oil cloth, then a layer of coarse brown paper, and, lastly, another sheet of finer and partially glazed brown paper. The cloth is put on the top of this in such a position that the hoops will encircle the bale at each end the same. Successive

sheets or layers, commencing with the last mentioned, are put on the top of the bale, ending with two strong iron hoops, the hydraulic machine is set to work, and the cloth compressed, under enormous pressure, to about one-half its original bulk. The first paper is then carefully wrapped round the goods and folded in at the ends, and the remaining alternate layers of material treated similarly, till the course external wrapping cloth is arrived at, which is folded over the bale and sewn along all the four with strong twine. The strong iron hoops are then bent over the bale, so that the bottom and top hoops will overlap each other at the middle of the sides of the bale; two oblong holes are then pierced through the two iron straps, and two strong pieces of iron, like paper fasteners, introduced into these holes, and then flattened out and fixed by means of powerful pincers. This operation is made at the three other places when the hoops overlap each other, and the bales is ready for shipment.

PRECAUTION IN PACKING.

This care in packing is necessary to prevent, as far as possible, the admission of moist air or moisture to the goods, and thus to keep them dry, because nearly all gray cloth goods contain a larger or smaller proportion of size, or flour mixture, and a small amount of moisture settling on the goods, especially in warm climates, would generally result in forming the size into a proper pabulum for the mildew, which is a name for the growth of various species of fungi, the seeds of which are generally present in large quantities in the fabric; and when the growths once commence, they are likely to penetrate fold after fold of the cloth, first attacking the size and then extending their destructive effects to the cloth; so that, in some cases, they may entirely destroy all the cloth in the bale, making it as rotten as tinder. The actions of these fungi are twofold; they grow with enormous rapidity, sending out microscopic filaments much more numerous than the filaments of the cotton itself, in all directions, which penetrate the cotton filaments, and thus mechanically weaken the threads; and the spores will feed first upon the size, and then upon the cotton itself, converting it slowly, but surely, into carbonic acid and water, the same effects which are produced when the cloth is burned. These fungi show their destructive effects in bales of goods in all degrees, from the effects just described to forming on the sides of perhaps only a few pieces in a pale slight yellowish or brownish stain.

MILDEW.

The history of mildew is most interesting. The question has, no doubt, struck many who have looked upon a bale of goods thus injured—How has the mildew got there? or, What is mildew? From the researches of Pasteur, an eminent French chemist, and others, during the last 15 or 20 years, the subject has, so far at all events as this is concerned, been thoroughly investigated. The size, after being boiled, is absolutely free from any living spores of fungi, and mildew cannot take place unless these spores are afterwards sown upon the cloth. The question then comes, But where do these mildew seeds come from? The answer is, They float in the atmosphere, and that the atmosphere of our rooms and factories is very far from being pure may be shown by looking at the beams of sunshine as they pass through our windows, the significance of which was recently brought before us by Tyndall. In the beams of sunshine we see myriads of minute particles floating about; a large number of these particles are seeds or mildew spores, and they fall on everything that is in their vicinity; they fall upon the warps and weft of our manufactures, and when they find they have a good soil, they burst into a luxuriant growth, and destroy his cloth.

I have here two ordinary glass shades, each half filled with flour paste, and we know that if flour paste be left exposed to the air, within a few days its surface will be covered by copious growths of fungi; but, with the view of showing that it is quite possible to keep this substance free from mildew, simply by excluding the floating particles or spores in the air, I boiled in a basin some flour with water, at the same time having placed water in two glass shades standing mouth upwards—the water in each of these was boiled. Over the open end of one of the shades, I tied two pieces of cotton cloth, between which I had previously placed a layer of cotton-wool, the steam from the boiling of the water was allowed to act upon the cloth, to allow the heat to destroy any mildew spores which adhered either to it or the sides of the glass; the cotton-wool cover was then quickly taken off, the boiling water poured out, and immediately afterwards the starch paste poured into it so as to half-fill it, and immediately after this, whilst everything still remained, the layer of cotton-wool was replaced over the mouth or open end of the shade, and tied at the sides of the glass with a cord—on the other one no covering was placed. This experiment was made three weeks ago, and the results speak for themselves. The surface of the paste in the uncovered vessel is now thickly covered over with mildew growths, whilst the covered one is quite free from it, and appears now as fresh as the day on which it was prepared; and yet the air had equal access to each, the only difference being that in the one case the air which came to the surface of the paste had to filter through a thin layer of cotton-wool, whilst it came in contact with the other without filtration. The idea of using cotton-wool for filtering spores from the air was first suggested by an eminent physician (Dr. William Roberts, of Manchester). At the top of a high mountain, and especially after rain, the air is practically free from dust, and I venture to say that, if the works of a cotton manufacturer could be transferred bodily to the top of, say, Mont Blanc, and the sizing and weaving conducted there, taking the precaution to heat to the temperature of boiling water all the materials which came in contact with the cloth and size, to destroy the infection carried from our less elevated and infected atmosphere, that the goods might be left damp for any length of time, and yet they would not mildew; and if carefully packed so that the germs of our infected atmosphere could not get to the cloth, which would not be a difficult matter, the goods could then be transferred to the most filthy parts of our atmosphere, and although packed damp, they might be shipped to warm and damp climates without fear of any damage resulting to them from mildew or any kind of decomposition to the size contained in them. If, however, the packing were to be torn, then the ubiquitous spores would fall on the cloth, grow luxuriantly, spread, and ultimately destroy the entire bale. I believe that the lesson to be learned from the study of these points is a practicable one to a large extent, and may be applied to the mills of Lancashire. If they be ventilated with a copious supply of air, which has previously been filtered through cotton wool, it will go a long way toward the extermination of mildew in cotton goods, and consequent enormous losses which from time to time the merchants and manufacturers in Lancashire have suffered.

If we look to the arrangements of many sizing machines, we observe that the warp is passed over hot cylinders when they are partially dried, and the drying is completed by means of a fan, which blows a current of air against the damp threads; this air, being unfiltered, contains myriads of mildew spores floating in it, and the force with which they are thus thrown against the damp threads cause them to stick, and thus the manufacturer is careful to sow these seeds of destruction along every part of every thread of his warp, and so he has to prevent them from growing by keeping his goods quite dry, or by adding to his size a powerful antiseptic; but whether or not manufacturers use all care possible to prevent mildew, there is often carelessness shown in packing, over which they have no control; and, again, if that process be conducted satisfactorily, the bales may be treated carelessly after they have been shipped, and all or any of these may result in the damage or total destruction of the goods.

DAMAGED GOODS.

It then often becomes a question, when goods have been damaged, to find upon whose head the loss ought to fall, or who is the guilty party, and to decide the question, the best plan which can be adopted is that which is now often practised, viz., to have an unopened bale returned from abroad, but this sample bale on its arrival is often so treated by the recipient of it, that a large proportion of the evidence against the offending party is lost. When such a bale arrives, the outside should be carefully examined for flaws in the packing, or mud or other stains on the outside wrapper, and the results noted in writing; the iron straps should then be removed, and the bale carefully undone, leaving each wrapper in position so that it may be replaced in exactly the same position which it originally occupied; any stains or flaws on any of the wrappers should be carefully noted, then all the six sides of the block of cloth should be carefully examined, and if any stains be found on them their position should be compared with the positions of any stains or flaws on the packing. It sometimes happens that salt or fresh water may have been thrown on it, or by some means allowed to come in contact with the bale, so that it has penetrated the packing and come in contact with the cloth, in this case distinct water stains will be observed, and this at once shows that the bales have been treated carelessly. The question which next arises, and the answer to which will go far to fix the blame on the offending party, is this, Have the stains been produced by fresh or salt water? If the latter, it will show that the damage has resulted during shipment, or at all events when it has been in the vicinity of the ocean; this point may be roughly tested by touching the tongue first with part of the unstained and then with the stained part of the packing. It happens often that the peculiar saline taste of salt can be detected on the stained portion, whilst that taste cannot be detected on the unstained parts; this point can, however, be more surely detected by chemical means. Equal parts by measure of the stained and unstained portions of the paper wrappers should be taken, because the water will come in contact with them before it touches the goods; these pieces should then be cut into bits, and put respectively into two different glasses, the same bulk of pure distilled water should then be added to each, and allowed to soak therein for some hours; a portion of each solution should be transferred to a test tube, a few drops of pure nitric acid added to each, and then a few drops of a solution of nitrate of silver; if the solution from the stained portion turns of a milky color, owing to the presence of chlorine, whilst the other does not, you are justified in assuming *prima facie*, that the stain has been produced by sea water; but as "salt" is a combination of chlorine and sodium, it is advisable to prove the presence of the latter substance also, which may be done generally by dipping a fine clean platinum wire in the solution from the unstained portion, and placing it in the flame of a Bunsen's burner, and observing the color which it communicates to the flame; the wire is then dipped in the solution from the stained portion, and if the latter communicates to the flame a much brighter yellow color than the former, it may be taken as almost certain that salt water is responsible for the error, which can be further demonstrated by testing for other salts known to be present in sea water.

The cloth should then be examined by separating several of the pieces and examining each, fold after fold, to observe whether the damage has gone completely through each piece or not, and the results noted; the pieces should then be replaced in exactly the same positions in which they were found, in case other points might suggest themselves which it would be advisable to examine. My experience in these cases shows me that seldom are any of these points attended to. The bale is generally opened carelessly, the packing thrown about in all directions, the pieces of cloth separated from each other and tumbled about indiscriminately, and it often happens that after this treatment, when they have thus destroyed most of the evidence, they request a professional man to give his opinion as to the cause of damage. I mention these things specially, because they are often important matters, about which both merchants and manufacturers seem to have but little knowledge.

Much reform is required in the interesting but conservative process of "sizing," which I have here briefly tried to describe, and I shall be pleased if this paper, or collection of facts, should count as one brick toward the completion of the edifice where "sizing" shall be worked upon perfect scientific principles.

NOTES ON GARMENT DYEING.

PREPARATION OF GARMENTS WITH COTTON WARPS.

In many dye-works articles before being dyed are cleaned with soap, and then rinsed. Although this treatment cannot be pronounced irrational or bad, it is not to be recommended to every dyer. An inequality in the manner of rinsing the washed garments often produces spots or shades during dyeing. In dye-works not provided with soft water, other means are used in place of soap. The best agent for cleansing is carbonate of soda. A somewhat concentrated lye generally removes the greater part of the spots.

To cleanse twenty garments for dyeing, a beck of the needful size is filled with water at 155 deg. F., in which 4 lbs. 6 ozs. of soda crystals are dissolved. In this the goods, well spread out, are allowed to steep for four or five hours. At the end of this time the garments are taken out, one by one, and spread upon a very clean table close at hand. A strong and hot lye of soda is prepared in a pail, and such parts as are spotted with grease, etc., are treated therewith, with the aid of a hard brush, till they disappear.

To remove hardened spots of stearine, paraffin, tar, resin, etc., benzine (not benzoline) must be used. A rubber is steeped with it, and applied to the spot till it is completely removed. The rubber thus used, instead of the brush, is formed of a piece of woolen cloth rolled tightly up, and covered with a small piece of cotton or linen. The whole must be large enough to be grasped firmly in the hand.

In well organized dye-houses no garment is washed in rivers, but in properly arranged washing machines.

GREEN ON GARMENTS WITH COTTON WARPS (11 LBS.).

Mordant for an hour at a boil, with 2 lbs. 8 ozs. alum, 8¾ ozs. tartar, 4½ ozs. sulphuric acid, 6¼ ozs. extract of indigo, 2 lbs. 3 ozs. fustic. Put it then in a fresh beck, containing 17½ ozs. alum, and the same weight of fustic. Work for an hour, lift, and enter in a fresh beck, with 2 lbs. 3 ozs. sumac.

Leave it in this latter beck for two hours, turning it from time to time. Lift, ring, and dye in a fresh cold beck, with methyl-green. For deeper shades extract of logwood may be added.

BROWN ON GARMENTS WITH COTTON WARPS (11 LBS.).

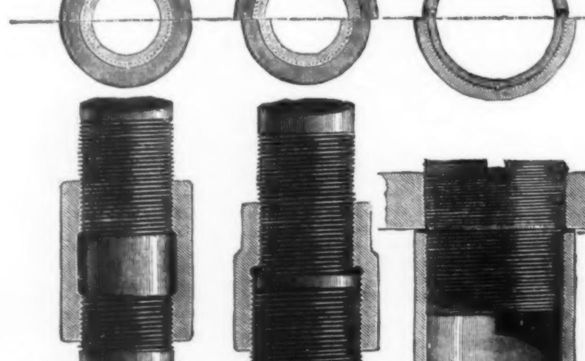
Make a decoction of 2 lbs. 3 ozs. catechu in water; decant the clear liquid, and add to it the solution of 5 ozs. bluestone. Enter the garment, spread out, and steep for an hour. Lift, press, and enter in a boiling beck, made up in the proportion of 1 lb. 10 ozs. argol, and 17½ ozs. bicromate of potash. Boil for half an hour, then lift, and dye for the same length of time with 2 lbs. 3 ozs. peachwood, and 17¼ ozs. fustic. After boiling for half an hour, lift, and examine if the shade is as required. If not, it may be reached by an addition of peachwood, fustic, or logwood, keeping up the boil. If the cotton is not of the same shade as the wool, 3½ to 5¼ ozs. of alum is added to the dye beck, and the goods are re-entered, but not boiled.

BLACK ON GARMENTS WITH COTTON WARPS (11 LBS.).

Dissolve 8¾ ozs. solid extract of logwood in boiling water, and boil the goods in this. Lift and boil for 45 minutes in a fresh beck, made up with 8¾ ozs. bluestone, and 12 ozs. copperas. Return to the first logwood beck, to which 5¼ to 7 ozs. of soda ash has been added. If the color is not full enough, add a little more extract of logwood. Sadden with 2¼ to 3½ ozs. copperas.—*Teinturier Pratique.*

DIFFERENTIAL SCREW PIPE JOINT.

We illustrate above a differential screw coupling for pipes, by M. E. A. Bourry, of St. Gallen, Switzerland. The arrangement consists in screwing the ends of the pipes to be con-



DIFFERENTIAL SCREW PIPE JOINT.

nected with threads of different pitch, and employing unions tapped with corresponding threads, this combination increasing the power available for making the joint in the proportion of the difference of the pitch, and at the same time facilitates the disconnecting of the joint. Fig. 1 shows the connection of a tube to a plate by means of a screw ferrule, the finer thread of which is on that part entering the plate, a metallic washer being introduced between the end of the tube and the underside of the plate. Fig. 2 shows a joint with two pipes of unequal diameter, by means of a tapped union and a metallic washer interposed. Fig. 3 shows the union of two pipes of the same diameter. In this case the end of one pipe is left unscrewed for a distance equal to the length of coarser thread in the union, to allow of the latter being run back on the pipe before the joint is made.—*Engineering.*

[Journal of Gas Lighting.]

PIPES FOR GAS AND OTHER PURPOSES.

(Continued from Supplement No. 77.)

Main-Laying.

The ordinary appliances for drilling mains for connecting service pipes are the ratchet-brace and diamond-pointed drill, Fig 17. In using these, there is necessarily an escape of gas until the hole is completed and tapped, and the service pipe inserted. Various instruments, however, have been invented

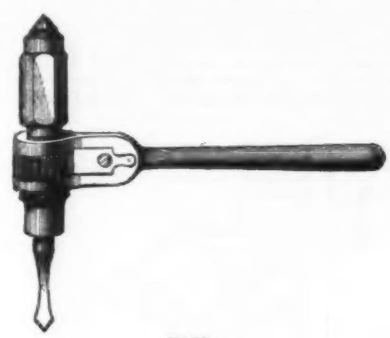


Fig. 17.

for performing the work without loss of gas, thus obviating not only the escape but the risk of accident attendant thereon.

The apparatus invented by Mr. Upward, shown in Fig. 18, answers the purpose admirably. The drill post is secured to the main by a clamp chain, which serves for a variety of pipes of different diameters. The cutter, which is of the construction shown in the engraving, works in an airtight cylinder. When the ratchet-brace is turned by the handle in the usual way, the cutter, on being fed by the screw, makes a circular channel in the iron, which is gradually deepened until a small button is cut out. This button is held in a hollow at the bottom of the drill, and is withdrawn with it. The feeding screw is telescopic in construction, in order to admit of the apparatus being worked in a space where the room is limited. As soon as the hole is formed, the tapping begins, and is completed when the tap comes home to the shoulder. The piston tap and drill are then removed by working the ratchet backwards, and the valve at the side is closed. A cap, fitting to the cylinder gastight, and having a vulcanized india rubber top, is now put on, the service pipe is inserted through a door in the cap, and on the valve being opened is screwed up and completed.

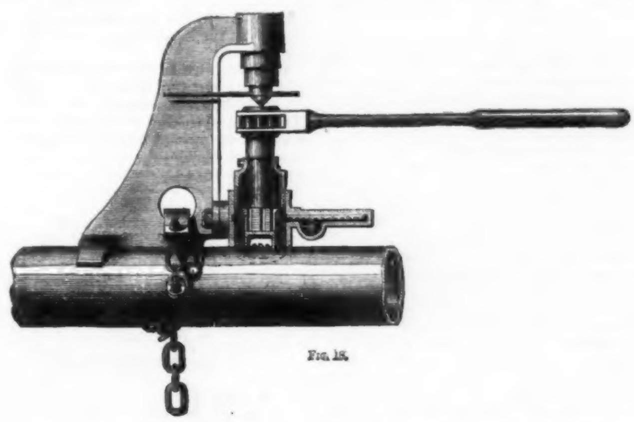


Fig. 18.

With this apparatus, all the operations of drilling, tapping, and inserting the service pipe are accomplished in a quarter of an hour or twenty minutes, without the least escape of gas, and hammers, chisels, gouges, and rymers are entirely dispensed with. In confined situations, and in deep cuttings in the vicinity of cellars, into which there is a liability of any escaping gas entering, and in subways, the use of this apparatus is invaluable.

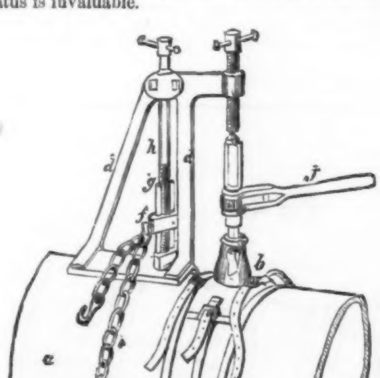


Fig. 19.

Mr. Rafferty also devised an apparatus of the kind, which will be readily understood from Figs. 19 and 20 and explanation. The apparatus consists of a small bag made of india rubber, in the form of a frustum of a cone, fastened to the gas main by straps and buckles. In the interior are fixed self-acting closing and opening doors, made of overlapping flaps of india rubber, to allow the drill, rymer, and tap to be introduced or withdrawn, as required. These latter are worked in the ordinary way by a ratchet brace, which is supported by a light stand firmly chained to the gas main.

The accompanying engraving is a view in perspective of the apparatus when in operation; *a* represents the gas main to which it is required to connect a service pipe, a cock, or a plug; *b* is a bag made of india rubber, within which are the valves or doors, *c*, shown in section in Fig. 20. The upper one is formed by cutting a slit in a disk of india rubber, and the lower one consists of two overlapping flaps; these doors yield to allow the tool to pass; and when this is withdrawn they close again by their own elasticity, and prevent the escape of the gas. A ledge is made all around the base, forming a recess, to receive the borings in drilling the hole and in screwing. The stand, *d*, is secured to the main by the chain, *e*, which passes under the main, and is hooked to the bridle, *f*, guided by the studs, *g*, and raised by the screw, *h*, to tighten the chain. The stand, *d*, also supports the screw, *i*, the end of which bears upon the end of the ratchet brace, *j*.

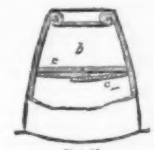


Fig. 20.

The mode of operation is as follows: When the stand, *d*, has been secured to the main, the requisite hole is bored through about three-fourths of the thickness. The gas bag, *b*, is then placed in position, care being taken that its center corresponds with the center of the hole that has been partly bored. The drill is then passed through the gas bag, and the hole is completely bored through, rymered out, and tapped by the usual tools. The drills, rymers, and taps are made with a shoulder resting on top of the gas bag, and this, as the tool penetrates the main, serves as a joint to prevent the escape of gas. When the hole is screwed it is ready for the service pipe, cock, or plug; but, before removing the gas bag, it is closed by re inserting the drill, which has a recess near its shoulder to receive an india rubber ring, and this ring prevents the escape of the gas while the apparatus is removed, and the service pipe, cock, or plug is got ready.

FITTINGS OF GAS AND WATER PIPES.

All pipes, of whatever size or description, branching out from the main pipes for the distinct supply of gas to the premises of consumers, public lamps, etc., are called service pipes. Those for the supply of extensive works, mills, factories, large railway stations,, theaters, etc., are of cast iron, and vary in size from 3 inches diameter and upwards, whilst the great majority of service pipes are of wrought iron tube from $\frac{3}{8}$ths of an inch up to 2 inches bore (Fig. 1).

By the term "service fittings" is meant the short pieces of wrought iron pipe, equal and diminishing, either straight, as connecting pieces, (2), ferrules (3), sockets (4), nipples (5), caps (6), plugs (7), and backnuts (8), angular, as elbows (9), square and round bends (10), springs (11), tees (12), and crosses (13), uniform or irregular in size or diameter at their different ends, which are used to join the wrought iron pipes together in straight lines, or at angles to each other, by means of screw-threads on the pipes and fittings.

Wrought iron tubes and fittings, to be good, should be perfectly cylindrical, with no ribs or flat places, and internally as smooth as possible. The welding should be scarcely discernible from the other parts, and the screw should be equally deep throughout the thread.

In the manufacture of service pipes of wrought iron, it is of paramount importance that there should be uniformity of screw pitch amongst the different makers. In England this uniformity prevails, but in Scotland each maker follows the bent of his own inclination in this respect, the consequence being an amount of confusion and inconvenience, leading to bad jointing and loss of time in recutting the threads, which we are at a loss to understand should be tolerated for one month.

Wrought iron pipes of smaller internal diameter than $\frac{3}{8}$ths of an inch should never be put in the ground. There is no economy in their use. They are soon filled up with dirt and scale; if the gas is at all impure, they become clogged and contracted in their bore. The friction of the gas passing through them is enormous, and if their length is great, a high initial pressure has to be maintained to force the gas through them to give the necessary supply. The expense of labor in laying them is also as great as for pipes of larger size.

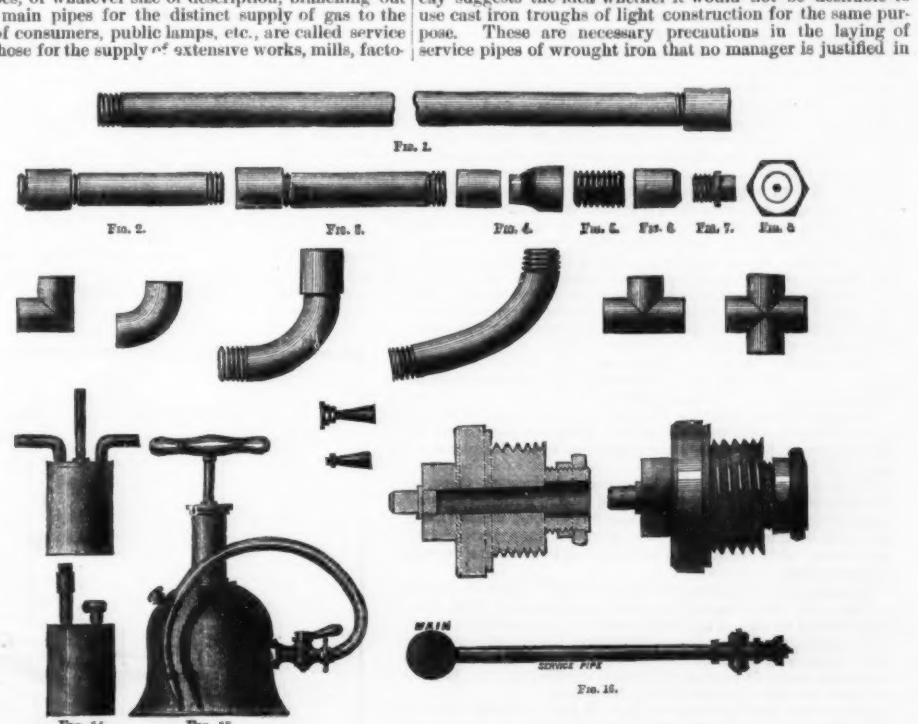
All wrought iron pipes, if laid in the ordinary unprotected way, are subject to rapid oxidation in the ground. This is especially the case in made ground, filled up with ashes and the refuse of iron and chemical works. Under such conditions they may not be expected to last beyond two or three years. In open, porous, gravelly soil, also, through which the surface water percolates rapidly, their destruction is rapid. This is also the case in sandy soils in proximity to the sea, and impregnated with saline matter. In all such circumstances, it is of advantage to employ galvanized pipe, and that, too, of a strength greater than is otherwise necessary.

The average life of wrought iron service pipes, as generally laid, is about eight years. They are the least durable part of the distributing plant of a gas undertaking. From this statement we may realize to some extent the enormous corrosion that is constantly taking place in these pipes, the incessant renewal that is required, necessitating the tearing up of the ground, with all the waste, annoyance, and expense attendant on the process. All this may have been unavoidable, and in a large degree excusable, in the earlier years of gas lighting, when experience had to be gained, and the art of canalization had to be learned; but it is excusable no longer, when, by the use of obvious precautions, the life of pipes may be prolonged greatly beyond the time mentioned.

Putting aside the recent discovery of Professor Barff, whose process of preserving iron, if it answers the expectations entertained of it, and can be generally and inexpensively applied, will vastly extend the use of ironwork of every kind, and enhance its value in those circumstances where its use is at present indispensable, there are other expedients that may be, and are, resorted to by thoughtful gas managers and engineers. These are the careful protection of the pipes by thickly embedding them in soil, or surrounding them, under and over, with clay, brought from the nearest accessible place, if these materials are not already found in the newly opened trench.

Another practice, also to be highly commended, and which has been extensively adopted by The Gaslight and Coke Company in the Metropolis, is that of placing the pipe in a slight wooden trough, made of half-inch laths, three inches broad, left rough from the circular saw, and either V-shaped or U-shaped in section, into which, after the service is completed, melted pitch is poured, surrounding the pipe from its junction with the main to the wall of the premises being supplied, and completely protecting it from the deteriorating effects of air and moisture. The liability of the wood to decay suggests the idea whether it would not be desirable to use cast iron troughs of light construction for the same purpose. These are necessary precautions in the laying of service pipes of wrought iron that no manager is justified in neglecting to use, and which, indeed, he will not fail to adopt if he cares for his own reputation, and the interests of those by whom he is employed.

The great bulk of the leakage of gas is unquestionably to be traced to the service pipes, either from defects in the pipes themselves, or by corrosion, or at their junction with the mains. It follows, therefore, that the best results would arise from more careful manipulation here, and the employment



FITTINGS FOR GAS AND WATER PIPES.

of the best materials. This latter is a point on which something must be said. With some persons, it would appear that the chief recommendation for the adoption of the pipes of any maker is the amount of discount that such is able to allow from the ordinary list price, the strength or quality of the metal composing the pipes being quite a secondary consideration. This ridiculous parsimony, it must be admitted, is more often an attribute of directors than managers, the opinion of the latter being frequently overruled in this as in other matters.

It is desirable to prove all service pipes when they are received from the manufacturer. This can readily be done by plugging one end, and attaching a hand syringe to the other. On immersing them in a shallow cistern of water, and compressing the air into them, defects will be indicated by the air-bubbles rising through the water to the surface.

Wrought iron is not the only material used for service pipes. These are sometimes of cast iron down to the smallest size. Composition and tin pipes have also been tried, and lead piping, which has much to recommend it, is used exclusively by some engineers.

Cast iron service pipes are of great durability; but the drawbacks attending their use are such as to counterbalance any advantage in this respect. They are necessarily made in short lengths, not exceeding 6 feet long each, and the number of joints, and the consequent risk of leakage, is greater with them than with most of the other pipes mentioned. Their liability also to fracture, by settlement of the ground and overhead traffic, is obvious, and their first cost in material and laying is greater than either wrought iron or lead.

Composition pipe is not suitable for placing in the ground, as it is rapidly destroyed by contact with the soil and moisture. Pipes made of pure tin are exceedingly durable; but the cost of the material necessarily precludes its extensive use for this purpose.

Lead pipes are slightly more expensive than wrought iron, but they cost less in laying; they are more durable in most soils, and when they require to be replaced, the old material is intrinsically of value for remelting. The objections to their employment are their liability to sink after being laid, and to be crushed and flattened, or otherwise injured, in the opening of the ground by workmen. These objections, however, can be overcome to a large extent by laying the pipes either on wood slabs half an inch to three quarters of an inch thick, and protecting them by a similar covering, or by providing wooden troughs for their whole length, and embedding them in pitch as recommended for wrought iron pipes. In connecting them to the main, the latter is drilled and tapped in the usual manner, and a brass ferrule is inserted having a union joint, to which the lead pipe is attached by soldering. This is the only joint that requires to be made between the main and the consumer's meter, and this absence of joints and couplings is no slight recommendation in their favor. In Paris the services are principally of lead, protected by earthenware tubes, through which the pipe is passed.

We spoke of the great importance of having uniformity of screw-pitch in the manufacture of service pipes and fittings. The following table will be found useful in connection with this subject:

Pitch of the Whitworth Taps and Dies for Gas Tubing.

Diameter of tube in inches.....	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
No. of threads per inch......	28	19	19	14	14	11	11	11	11	11

No gas company, or local authority supplying gas, should allow the control and work of service-laying to pass from the hands of their own responsible servants into those of independent gas-fitters. The work is too important to be delegated. Every division of a gas manager's duty calls for the display of skill and constant watchfulness, and the exercise of these qualities in this, as in other departments, is fully repaid.

In laying service pipes, the sockets supplied with each length should always be removed, the thread painted with red lead, and the socket replaced.

The holes in mains, for the insertion of service-pipes, should invariably be drilled, not gouged or cut with a chisel, as is too frequently the rule. In drilling, when this is carefully done, the full thickness of metal is retained all around the hole, and this is true in outline; whereas in cutting with the chisel it is impossible to insure a mathematically correct circle, or to avoid breaking pieces off the inner edge, thereby reducing the thread-area necessary for making a satisfactory joint.

Before inserting the pipe, a thin back or check nut should be run on the end, along with a galvanized india rubber or felt washer, and when the service pipe is screwed up this nut is gently tightened against the main, its effect being to insure a better connection by causing a closer contact of the threaded surfaces than is otherwise attainable. To simply screw the service pipe into the main is not a satisfactory method of jointing. A brass ferrule, having a shoulder and coupling screw, is used for the same purpose, but this adds to the cost without securing a better result.

It is desirable in service pipes to have as few joints as practicable, and, therefore, the several lengths should be as long as can be conveniently placed.

The pipe, throughout its length, should be firmly bedded, to avoid settlement, with the risk of drawing the thread, or the danger of producing slack places and the lodgment of water.

The iron service pipe should be carried through the wall of the building to be supplied, and the part within the wall painted with tar, to prevent oxidation; its end should then be carefully secured with a cap, rendered gastight with red-lead paint, until required to be connected with the stopcock and the meter.

It is advisable sometimes to insert a short piece of pipe—say 10 or 12 inches in length—having a long screw or running thread on one of its ends, near to the junction of the service with the main, for convenience in disconnecting the pipe, in case of an enlargement of the mains. This expedient obviates the necessity of much opening of the ground to reach the first joint in the service pipe.

Wherever practicable, the service pipe should have a slight rise from the main, and, when this cannot be accomplished, a small cast iron syphon pot or receiver, Fig. 14, must be placed underneath it at the lowest point, to allow any water to drain into it. This may be either occasionally pumped dry with a hand pump, or a screw plug may be inserted in the bottom of the vessel, which, on being removed, will permit the water to escape.

Abrupt angled elbows should be avoided as far as possible, as tending to produce eddies, and interrupt the even flow of the gas; circular bends are preferable, whenever they can be employed; but bends of every kind should be dispensed with, if a straight length of pipe can be made available for the supply.

Most companies lay the service pipe from the main, through the wall of the consumer's premises, free of charge, if the distance does not exceed 8 or 12 yards, except in the instance of passing through private property, when a charge is made for the work and materials.

The renewal of service pipes, when they have been long in use, should be systematically carried out. The cost of doing this will be repaid by the diminished leakage.

Obstructions, such as naphthaline, grit, water, or rust, in service pipes, are readily driven forward into the main by means of the service cleanser of Messrs D. Hulett & Co. This is represented in Fig. 15, and consists of a strong bell-shaped vessel, to the top of which a force pump is fixed. A strong flexible tube, tapered at the end, to fit into the pipe to be cleaned, is attached to a branch in the side, fitted with a stopcock. The pump or syringe is then worked, and the vessel charged with compressed air, and on the stopcock being suddenly opened, the rush of air removes the obstruction.

This service cleanser, at the suggestion of Mr. Mann, has been improved by fixing a bent pipe inside the air vessel from the cock, by which it is made available for discharging about a gallon of water with great force through the service pipes into the main.

The cleanser may also be used for the internal fittings of a house, but in so applying it, care must be taken to remove the meter and the hydraulic slides previous to attaching the apparatus.

Another useful contrivance for the like purpose has been invented by Mr. Goldsmith, shown in Fig. 16. It consists of a hollow brass nipple with shoulder, and screwed for attaching to the pipe socket. In using the cleanser, it is filled with ordinary gunpowder, and the opening is covered with a piece of thin paper, kept in position by a brass cap or collar. The cleanser is then screwed into the socket on the service pipe, a percussion cap placed on the nipple, which projects from the opposite end, and when exploded by a slight tap from a hammer, the powder is fired, and the obstruction driven out. The mode of application is shown above.—*Journal of Gas Lighting.*

ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

Article IX.

On the Dividing-Engine, and on Methods of making accurate Linear Scales.

DIVIDING-ENGINES are of two kinds: one, which we describe in this article, is used for dividing the straight line into equal parts; the other divides the circle into degrees and fractions of a degree. There are also methods of dividing straight lines without the use of the dividing-engine, and four of these methods we will explain.

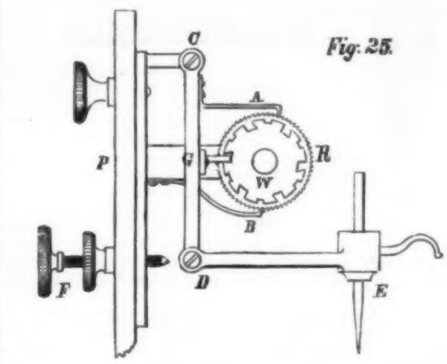
A linear dividing-engine consists essentially of two parts: (1) A sliding table which is moved in the direction of its length by means of a screw which works in a nut attached to the under surface of the table; (2) a cutting apparatus, by which a cutter is caused to move always in one and the same vertical plane, at right angles to the axis of the screw. By means of this mechanism one may cut on pieces of metal, or other material, scales with equal divisions or with divisions bearing to each other any required ratios.

From the above concise description of a dividing-engine, it at once appears that the accuracy of this machine depends on the fulfillment of two conditions, viz.: 1st, that the screw is so accurately made, or, at least, that its errors are so precisely known, that one can always move the table under the cutter through a determinate distance; 2dly, the point of the cutting tool must move in one and the same vertical plane, and thus really cut on the plate to be divided the distances through which the screw has moved the table of the engine.

Fig. 24 shows a dividing-engine of simple construction. By turning the crank H, the screw S can be rotated through any required number of revolutions, or fractions of a revolution, and thus the table T is pushed forward, under the cutter C, through a known distance. After each forward motion of the table the cutting tool is caused to descend on to the surface to be divided—(in the drawing the engine is shown dividing a glass tube into equal divisions)—and then, by pulling the handle C of the cutter, the point of the tool cuts a line. The jointed framework to which the tool is attached, and also the mechanism for giving the screw the successive amounts of rotation, will be described, with the aid of drawings 25 and 26.

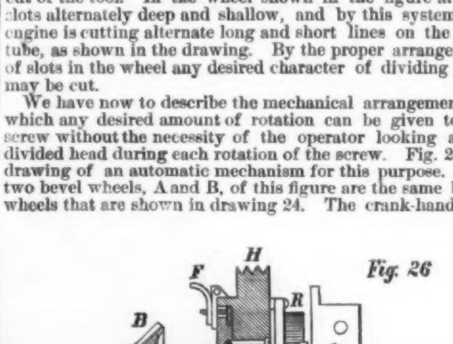
In Fig. 25 the plate P is the same as the plate P of Fig. 24. This plate is firmly screwed to the frame of the engine, and attached to it is the cradle carrying the cutter. In a ratchet wheel R, of Figs. 24 and 25, work two spring-pawls, A and B. To the side of this ratchet can be securely attached wheels, W, whose borders can be indented with various systems of slots. A short pin at G, which is fastened to the jointed plate, C D, is shown in the drawing at the bottom of one of the indentations.

The mode of action of this cradle is now readily understood. Suppose that the cutting tool has been lifted off the work and moved toward the plate, P, so as to allow the sliding plate of the engine to be moved forward by the screw. The amount that the tool moves backwards is regulated by the set-screw, F, against which the jointed plate, D, abuts. The amount of forward motion of the tool is determined by the pin coming against the border of the wheel, W, or against the bottom of one of the slots cut in its circumference. During this forward motion the point of the tool cuts a line in the work on the plate of the engine, and while the operator pulls the tool, E, towards him, the spring, B, holds the wheel, W, stationary, and the tool moves forward till the pin, G, reaches the bottom of the slot, as shown in the drawing. But when the tool is lifted from the work, and the cradle is

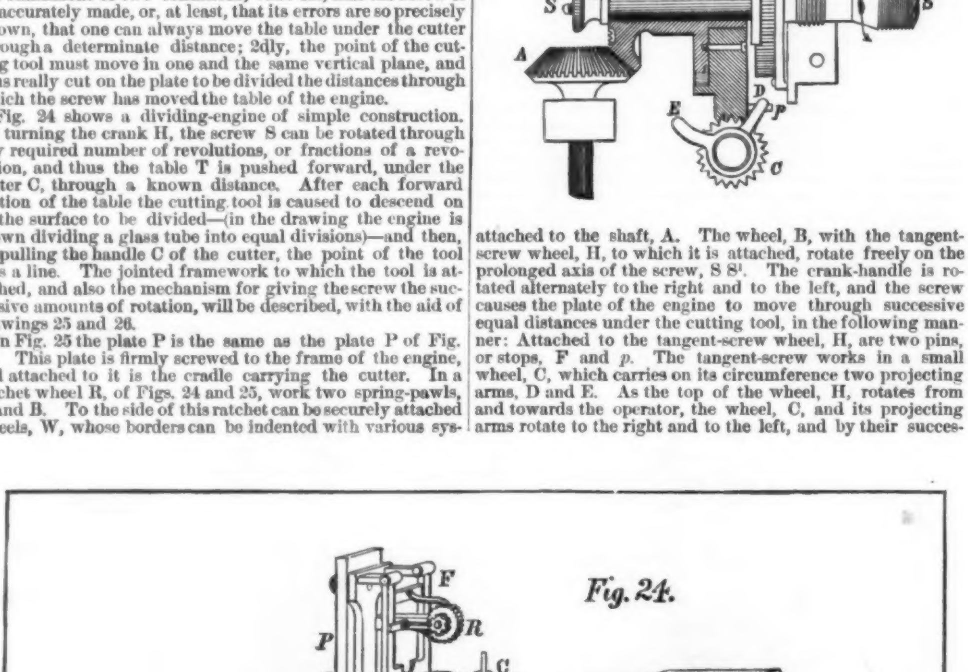


pushed from the operator, the pin, G, comes out of its slot and the spring, A, attached to the jointed plate, C D, turns the ratchet, R, and the wheel, W, until D comes against F; and thus either another slot or a portion of the border of the wheel, W, is presented to the pin, G, at the end of the next cut of the tool. In the wheel shown in the figure are cut slots alternately deep and shallow, and by this system the engine is cutting alternate long and short lines on the glass tube, as shown in the drawing. By the proper arrangement of slots in the wheel any desired character of dividing lines may be cut.

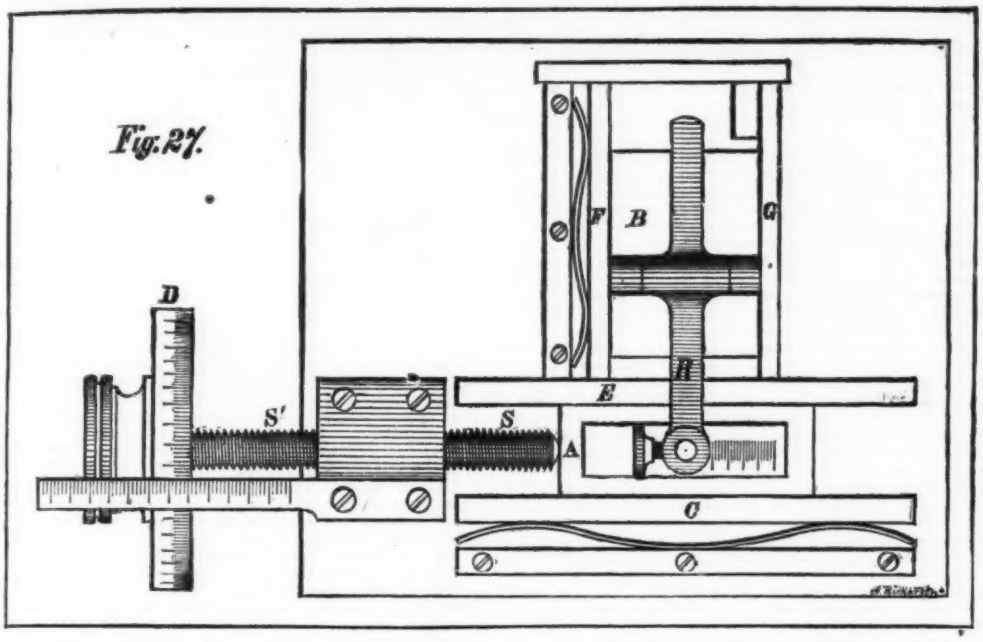
We have now to describe the mechanical arrangement by which any desired amount of rotation can be given to the screw without the necessity of the operator looking at its divided head during each rotation of the screw. Fig. 26 is a drawing of an automatic mechanism for this purpose. The two bevel wheels, A and B, of this figure are the same bevel wheels that are shown in drawing 24. The crank-handle is



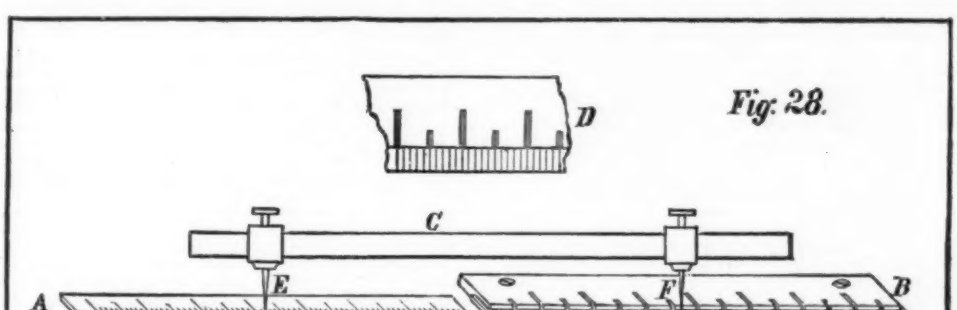
attached to the shaft, A. The wheel, B, with the tangent-screw wheel, H, to which it is attached, rotate freely on the prolonged axis of the screw, S S[1]. The crank-handle is rotated alternately to the right and to the left, and the screw causes the plate of the engine to move through successive equal distances under the cutting tool, in the following manner: Attached to the tangent-screw wheel, H, are two pins, or stops, F and *p*. The tangent-screw works in a small wheel, C, which carries on its circumference two projecting arms, D and E. As the top of the wheel, H, rotates from and towards the operator, the wheel, C, and its projecting arms rotate to the right and to the left, and by their succes-



sive motions the stops, F and D, are successively brought to bear against the projecting arms, E and D. In the drawing the tangent-screw has finished its motion away from the observer and has been brought to rest by the stop, *p*, having come against the projecting arm, D, of the wheel, C. The stop, F, can be clamped at various positions on the circumference of the wheel, H, and thus different "throws" can be given to the wheel, H. The wheel, H, moves the screw, S S', of the engine, as follows: Attached to the wheel, H, is a spring-pawl, I, which works in the ratchet-wheel, R, the latter being firmly fastened to the screw. Another spring-pawl, I', works on the same ratchet-wheel, R, and is attached to the stationary journal-block, G, in which works the collar of the screw. By this mechanism it is evident that when the top of the tangent-screw wheel, H, moves from the observer, the spring, I, takes hold of the ratchet-wheel, R, and the screw must turn with the wheel, H. When, however, the top of the wheel, H, moves toward the observer, the spring, I, moves over the ratchets of the wheel, R, while the spring-



pawl, I', holds the screw stationary. Thus the screw is moved through successive definite amounts of rotation, and the required amount of rotation of the screw is determined beforehand by the position of the stops, F and *p*. In Fig. 24, the stop, F, is shown at *f*, and the wheel, c^1, is shown marked as *c*. A comprehensive view of the action of the engine, shown in Fig. 24, is now readily grasped. Suppose that the screw has a pitch of one millimeter, and it is desired to cut a scale to tenths of millimeters, and also to have every tenth or millimeter line, on this scale, marked with a long line, while every fifth or half millimeter line shall be indicated by a somewhat shorter division line, and the intermediate divisions by the shortest lines on the scale. We first place the stops on the wheel, H, so that ten throws of the crank-handle are necessary to give one whole revolution to the screw. Then a wheel (W of Fig. 25) is selected which has two notches in its circumference directly opposite one another, and one of the notches is deeper than the other. Suppose the pin (G of Fig. 25) is at the bottom of the deeper of these notches, and while in this position, the stop, F, is against the arm, E. The tool now makes a cut in the work to be divided. The crank arm is rotated backwards, and another



other throw is given to the screw. At the end of this throw the tool, E, is pushed backwards, and when brought forwards in making the next cut, the pin, G, will come, not as formerly against the bottom of the notch, but against the border of the wheel, and this will take place until the fifth act, when the wheel, W, will present the shallow notch to the pin, G, and the first fifth division, by this means, will be indicated by a line longer than the preceding four divisions, but shorter than the lines which begin and terminate the millimeter.

If the engine we have described has a screw which is accurately one millimeter in pitch throughout and has its axis of rotation coincident with its axis of figure, while the cutter always moves in one and the same plane, then we can cut a scale of great accuracy with this engine. But these conditions are extremely difficult to obtain in the construction of a dividing-engine. In our next article we will describe the manner of making an accurate screw and will show how its errors can be detected and measured, and also how the screw can be connected for excentricity. We will also describe the method of determining the pitch of a screw.

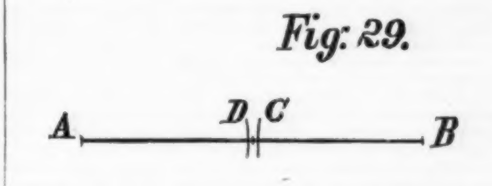
Fig. 27 shows a dividing-engine reduced to its simplest construction, and suitable for dividing short scales on small pieces of work. Against the rounded point of the screw S S' a plate A is constantly pressed by means of a cord and weight, not shown in the figure. The bowed spring keeps the plate A in close contact with the two guides E and C, and so causes the plate A always to move along the straight edge of E. In a similar manner the plate B, carrying the tool holder, and cutter R, is made to move parallel to the straight edge of the guide G. The plate A is made to move definite spaces under the cutting point by giving to the drum-head D of the screw the required rotations indicated by the divisions on the drum D.

The minute precision of the work of some dividing-engines is really astonishing, when we consider the fineness and extreme delicacy of the work which they have done. One of the most perfect we know of is that recently constructed by Mr. Lewis M. Rutherfurd, of New York. This engine cuts on glass or speculum metal nearly 20,000 lines in the space of an inch, and these lines are straight, parallel, and equidistant. This remarkable engine will be minutely described in the article which we will write on the manner of measuring the wave-lengths of light.

There are methods of dividing a line into equal parts which do not employ the dividing-engine. Some of these we will now speak of. Fig. 28 shows the method of making a scale by transferring the divisions of an accurately cut scale to the plate or rod on which we wish to cut equal divisions. The plate B, on which to cut a scale, is placed so that the line on it to be divided is in the direction of the prolongation of the scale A. A beam-compass, with its points distant three to four feet, is used as the transferring instrument. In the drawing the beam-compass is shown dividing the unit into ten parts, and each tenth and fifth division is indicated by a line longer than the other lines on the scale, and the tenth line is longer than the fifth. To obtain this character of division a guard is placed over the plate B, which is notched so that at each tenth and fifth line the cutting point of the beam-compass enters a notch in the guard-plate, and thus cuts a longer division line in the scale. The guard-plate is shown separately on a large scale at D, of Fig. 28. This method should be generally known, for it gives excellent results when used skillfully, and especially when two operators work it; one placing the point E of the compass carefully on the division line of the scale A, and the other operator makes the cut with the point F. This method is so superior to the rough one of making a scale by stepping it off by trial with dividers, as is usually practised by mechanics, that it should be universally used in the shop; especially since Brown and Sharpe, of Providence, R. I., have made their truly excellent scales cut on steel plate, whose prices place them within the reach of any mechanic.

Accurate scales can be "originally divided," as it is called, by any one of the three methods now to be described.

If we wish a scale which can be made by successive bisections of the unit, the following method is an accurate one. Suppose that the line A B represents the unit to be subdivided. With a beam-compass if the line is long, or with a pair of spring-dividers if the line is short, we strike arcs with the same radius AD and AB, which radius is nearly equal to half of the unit AB. Then with a magnifying glass we sight on the space on the line AB included between the arcs D and C, and we bisect with the eye and hand this minute distance, neatly marking the point of division. This operation is repeated on each remaining half of the line AB, and then on the quarters, and so on, until the unit has been subdivided to the required minuteness. Of course by this method we can only make scales whose number of divisions is always a multiple of two; for example, the scales divided will be like the inches on the common foot rule, into halves, quarters, eighths, sixteenths, thirty-seconds, etc. This is an accurate—probably the most accurate—method of subdividing a line into equal parts. It, however, requires skill and considerable patience; indeed, the method can only be used with effect by the most able artists. In this manner Bird made his celebrated scales; the method is at present used in Germany as a preparatory step in the "original division" of the circle of circular dividing-engines. Space will not allow me to enter into a minute description of the method of originally dividing a circle. Suffice it to say that this, the most difficult and delicate of mechanical problems presented to the machinist, is solved by first making, with the most extreme care, an originally divided linear scale of equal parts; and having attached a vernier to it, we take in the beam-compass from this scale a length which exactly equals the chord of an arc of 85° 20' of the circle to be graduated, and with this chord we strike



on the circle an arc of 85° 20'. By continued bisections this arc is subdivided into equal parts of 5' each. The 60° division can be obtained by a chord which is equal to the radius of the circle, and this arc of 60° bisected gives 30°, which added to the previous arc of 60° gives an arc of 90°. The reader is referred to an article on *Graduation* by the celebrated artist, Troughton, in the *Edinburgh Encyclopædia*, for the best account of the delicate and difficult operations involved in the division of a circle into degrees and fractions. This mechanical problem has tested to the utmost the combined skill of the first mechanicians and of the ablest astronomers of modern times.

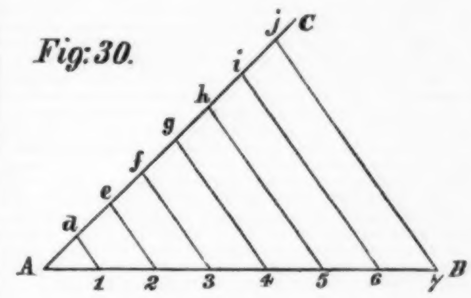


Fig. 30 will render clear a simple and ready method of dividing a given length into as many parts as required. Let A B be the line to be divided into 7 equal parts. Through the end, A, of this line draw the indefinite line, A C, making an acute angle with A B. Take in the spring-dividers any convenient length, *A d*, and with this length step off seven equal divisions on the line, A C. Through *j*, the end of the last of these divisions, draw the line, *j* B, passing through the end B of the line A B. Then through *i*, *h*, *g*, *f*, *e*, and *d*, draw lines parallel to *j* B. These lines will divide the line, A B, into seven equal parts, because A *d*, A *e*, A *f*, are to each other as A_1 A_2, A_3, are to each other.

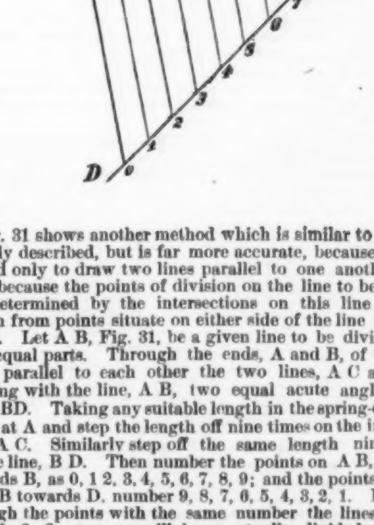


Fig. 31 shows another method which is similar to the one already described, but is far more accurate, because it is required only to draw two lines parallel to one another, and, also, because the points of division on the line to be divided are determined by the intersections on this line of lines drawn from points situate on either side of the line to be divided. Let A B, Fig. 31, be a given line to be divided into nine equal parts. Through the ends, A and B, of this line draw parallel to each other the two lines, A C and B D, forming with the line, A B, two equal acute angles, BAC and ABD. Taking any suitable length in the spring-dividers, begin at A and step the length off nine times on the indefinite line, A C. Similarly step off the same length nine times on the line, B D. Then number the points on A B, from A towards B, as 0, 1 2, 3, 4, 5, 6, 7, 8, 9; and the points on BD, from B towards D, number 9, 8, 7, 6, 5, 4, 3, 2, 1. Drawing through the points with the same number the lines 0, 0; 1, 1; 2, 2; 3, 3; etc., we will have actually divided the line, A B, into nine equal parts.

ON CATASTROPHISM.*

By CLARENCE KING.

WE have come together to-day to do honor to this young, strong institution. We are here that we may make the human circuit complete, and feel the current of a common pride glow from brain to brain. In celebrating the honest, manly growth of the Sheffield Scientific School, among the feelings which animate us, veneration for antiquity finds no place. It is denied us to look back into the real past, for the brief lapse of thirty years compasses the life of the school. That short period, however, has amply sufficed to develop, with positive distinctness, the motive and animus of the institution. Its peculiar character is fixed. Reverence for natural truth, and the deep, earnest scientific methods of searching after it, are what is taught here; so that we who have passed beyond these doors are gladly welcomed among the resolute band of nature-workers, who both propel and guide the great plowshare of science on through the virgin sod of the unknown.

It is centuries too late to define or establish the value of science. Its numberless applications which find daily expression in the material appointments of life, and serve to refine, to elevate, to render more admirable the mechanism of civilization, have long since put the question at rest. Let us hope that as a means of clearing away the endless rubbish of false ideas from the human intellect, for the lifting of a man out of the dominion of ignorance, scientific method and scientific education are acknowledged to be adequate, if not supreme. We may congratulate ourselves; for that victory is won. At last modern society admits that a knowledge of the laws which govern the cognizable universe and the possession of the only methods which can advance that sort of knowledge, presupposes, nay even develops, an intellect both vital and broad. If in America science as a mode of education has won her way to the front, it is due, in prominent measure, to the honest training of the Sheffield Scientific School, and time will render this institution its unfailing reward.

CATASTROPHISM AND EVOLUTION.

Honored by the invitation to address you to-day, I have chosen to present a contribution to the theory of Catastrophism and its connection with Evolution, feeling that, however slight this contribution may be, as my own, it is a direct outgrowth of this school, and that if I turn from the far greater and more attractive achievements of others, from the wealth of literary and philosophic materials which press forward for utterance, and bring here something which I have reached myself, it will afford you a more intimate interest. I have hoped, too, that other graduates will feel as I have, and that year by year men might stand here fresh from the battle-field of life, out of the very heat of the strife, to tell us of their struggles and hang the shields they have won along the walls of this temple of science. I ask you then to listen to a plain statement of my views of Catastrophism and the Evolution of Environment.

The earliest geological induction of primeval man is the doctrine of terrestrial catastrophe. This ancient belief has its roots in the actual experience of man, who himself has been witness of certain terrible and destructive exhibitions of sudden, unusual telluric energy. Here in America our own species has seen the vast massive eruptions of Pliocene basalt. The destructive invasion of northern lands by the slow-marching ice of the Glacial period has struggled with the hardly conceivable floods which marked the recession of the frozen age, has felt the solid earth shudder beneath its feet, and the very continent change its configuration. Yet all these phenomena are no longer repeated; nothing comparable with them ever now breaks the geologic calm.

Catastrophism is therefore the survival of a terrible impression burned in upon the very substance of human memory. The doctrine was also arrived at in very early times by our modern method of reasoning from marine fossils observed to be entombed in rocky beds far removed from the present seas; beds which compel the natural inference that they are sea bottoms upheaved. This induction is poetically touched in the Rig Vedas is stated in scientific method with surprising frequency among the Greeks, and recurs in the writings of most earth-students ever since.

Plutarch in his Morals gives a vivid account of an interview between an Egyptian priest and wise Solon, who, in the open-mindedness of a truly great man searching after immemorial knowledge, had come to sit at his feet to listen. Calmly and with the few broad touches of a master, in that simple eloquence which comes of really knowing, the priest tells him of the catastrophes of submergence and upheaval which the earth's surface has suffered, and his method was identically ours of to-day. What a picture! Solon the wise, inheritor of the Hellenic culture, master of the polished learning of his country and his day, sitting within the shades of that hoary temple, listening devoutly to the lips of one who spoke as out of the dark vault of the past, and told how the solid continents were things of a time, born but lately from the womb of the sea.

When complete evidence of the antiquity of man in California and the Catastrophes he has survived come to be generally understood, there will cease to be any wonder that a theory of the destructive in nature is an early, deeply rooted archaic belief, most powerful in its effect on the imagination. Catastrophe, speaking historically, is both an awful memory of mankind and a very early piece of pure scientific induction. After it came to be woven in the Sanskrit, Hebrew, and Mohammedan cosmogonies, its perpetuation was a matter of course.

From the believers in catastrophe there is, however, a totally different class of minds, whose dominant characteristic is a positive refusal to look further than the present, or to conceive conditions which their senses have never reported. They lack the very mechanism of imagination. They suffer from a species of intellectual near-sightedness too lamentably common among all grades and professions of men. They are bounded, I might almost say, imprisoned, by the evident facts and ideas of their own to-day and their own environment. With that sort of detective sharpness of vision which is often characteristic of those who can't see far beyond their noses, these men have most ably accumulated an impressive array of geological facts relating to the existing operation of natural laws. They have saturated themselves with the present *modus operandi* of geological energy, and culminating in Lyell have founded the British School of Uniformitarianism.

CATASTROPHISTS AND UNIFORMITARIANS.

Men are born either Catastrophists or Uniformitarians. You may divide the race into imaginative people who believes in all sorts of impending crises—physical, social, political—and others who anchor their very souls *in statu quo*. There are men who build arks straight through their natural lives, ready for the first sprinkle, and there are others who do not watch Old Probabilities, or even own an umbrella. This fundamental differentiation expresses itself in geology by means of the two historic sects of Catastrophists and Uniformitarians. Catastrophism, I doubt not, was the only school among the Pliocene Californians after their families and the familiar fauna and flora of their environment had been swept out of existence by basalts and floods. As understood by Archaic man, by the Orientals, the early Egyptian, the Greeks, the Arabs, and indeed until modified within the century by the growing belief in derivative genesis, or the unbroken continuity of organic life from its first introduction on the planet, Catastrophism was briefly this:

The pre-human history of the planet has been variously estimated in time from two days—the period assigned by the Koran—to an indefinite extension of ages. The globe having cooled from a condition of igneous fluidity, received upon its surface of congealed primitive rock the condensed aerial waters, which formed at first a general oceanic envelope, swathing the whole earth. Out of this universal sea emerged continents; and as soon as the temperature and atmospheric conditions were suitable, low organisms, both of the vegetable and animal kingdoms, were created and the complex machinery of life set in successful motion.

The great obvious changes in the rocky crust were referred to a few processes; the sub-aerial decay of continents, delivered by streams of land-detritus into the sea, the spreading out of these comminuted materials upon a pelagic floor, and lastly, upheaval, by which oceanic beds were lifted up into subsequent land masses. All these processes are held to have been more rapid in the past than now. Suddenness, world-wide destructiveness are the characteristics of geological changes, as believed in by orthodox Catastrophists. Periods of calm, like the present, suddenly terminated by brief catastrophic epochs, form the groundwork of this school. Successive faunas and floras were created only to be extinguished by general cataclysms.

From all these tenets the modern Uniformitarian school dissents only so far as to hold that the processes have not necessarily been more rapidly accomplished than at the rate we witness to-day. The facts of one school are the facts of the other. Both read the record of upheaval and subsidence, of corrugation and crumbling of the great mountain chains alike. One measures the rate of past geological action by the phenomena of to-day; the other asserts that the present furnishes absolutely no key. This irreconcilable difference finds its most pronounced expression when applied to the past history of life on the planet. If catastrophes extirpated all life at oft-repeated intervals from the time of its earliest introduction, then creation must necessarily have been as often repeated. If this is the case, it is plain that the Creator took pains each time to improve on the lately obliterated forms. If, on the other hand, the Uniformitarian biologists are correct in their belief of the descent of all animal life from one or a few primeval types, then catastrophes of a universally destructive character cannot have occurred, and the changes which are proven to have taken place in the earth's surface may have been as moderate and harmless as they maintain. The Uniformitarians reject rapid and destructive rate of geological revolution in the past, first, because the present course of nature offers no parallel suddenness of action, and, secondly, because they conceive that nature never moves by leaps. They derive great comfort from quoting the well known saying of Aristotle, that "Nature never does with her greater what she can do with her less." They are especially fond of objecting to catastrophes on account of the vast force necessitated. I confess that this seems to me a singularly fallacious view. Absolutely identical expenditures of energy are required to elevate a continent or depress an ocean basin given distances, whether the operation is instantaneous or infinitely slow. No geologist will hesitate a moment to admit that the question between the schools is not one of geological result, for both read the results alike. I am sure no student of energy will object to my statement that the result requires identical energy, whether employed after the uniformitarian or the catastrophic method. If, as I assert, geological result, and the energy to produce it, are identical, whichever school is correct, then the only issue between the contestants reduces itself simply and solely to the one question of rate of geological change. In that view, Uniformitarianism is the harmless, undestructive rate of to-day prolonged backward into the deep past. This is the belief hinted at by Aristotle and Pythagoras, fought for by Goethe, Lamarck, and Geoffroy St. Hilaire, held to by Hutton, Lyell, and most British geologists, accepted with a lover's credulity by nearly all evolutionists, and finally trumpeted about by the army of scientific fashion followers who would gladly die rather than be caught wearing an obsolete mode or believing in any penultimate thing.

On the other hand, Catastrophism of the orthodox sort is the belief in recurrent, abrupt accelerations of geologic rate of crust-change, so violent in their rapidity as to destroy all life on the globe. This idea, the mere survival of a prehistoric terror, backed up by breaks in the palæontological record and protected within those safe cities of refuge, the cosmogonies, was fully credited by so recent a great *savant* as Cuvier, and still counts among its soldiers a few of the cast iron intellects of to-day.

RADICAL UNIFORMITARIANISM.

Sweeping Catastrophism is an error of the past. Radical Uniformitarianism, however, persists, and probably controls the faith of a majority of geologists and biologists. A single extract from so late and so important a book as Croll's "Climate and Time" will serve to show how strong men still believe in what may be called homeopathic dynamics. Speaking of Uniformitarianism, Croll says: "This philosophic school teaches, and that truly, that the great changes undergone by the earth's crust must have been produced, not by convulsions and cataclysms of nature, but by those ordinary agencies that we see at work every day around us, such as rain, snow, frost, ice, and chemical action, etc."

Having reduced the antagonism of the two schools to a question of rate of transference of energy, a single illustration will serve to render clear how, the amount of energy remaining the same, this difference of rate may make the difference between uniformity and catastrophe. Suppose two railway trains of equal weight, each traveling at 50 miles an hour. On one steam is suddenly shut from the cylinder. The train gradually lessens and lessens its speed, finally coming to rest. It has required a given definite amount of resistance, a numerically expressible amount of work to overcome the motion of the train. The other train at full speed dashes against a bridge pier and is utterly wrecked. The weight, speed, and momentum of the trains were identical, and precisely equal resistance has been expended in bringing them to a stop. In one case the rate of resistance was slow, and acted merely as friction, quite harmless to life and after the uniformitarian mode. In the other, the rate of resistance was fatally rapid, and its result catastrophe.

GEOLOGICAL FEATURES OF A CONTINENT.

Remembering distinctly that Uniformitarianism claims one dynamic rate past and present, let us turn to the broader geological features of North America and try to unravel the past enough to test the tenets of the two schools by actual fact. Beneath our America lies buried another distinct continent—an Archæan America. Its original coast lines we may never be able fully to survey, but its great features, the lofty chains of the mountains which made its bones, were very nearly co-extensive with our existing systems, the Appalachians and Cordilleras. The canon-cutting rivers of the present Western mountains have dug out the peaks and flanks of those underlying, primeval uplifts, and developed an astonishing topography: peaks rising in a single sweep 30,000 feet from their bases: precipices lifting bold, solid fronts 10,000 feet into the air, and profound mountain valleys. The work of erosion which has been carried on by torrents of the Quaternary age—that is to say, within the human period—brings to light buried primeval chains far loftier than any of the present heights of the globe. Man's enthusiastic hand may clear away the shallow dust or rubbish from an Oriental city and lay bare the stratified graves of perished communities: it is only a mountain torrent which can dig through thousands of feet of solid rock and let in the light of day on the time-stained features of a long-buried continent.

Archæan America was made up of what was originally ocean beds lifted into the air and locally crumpled into vast mountain chains, which were eroded by torrents into true sub-aerial mountain peaks. This conversion of sea strata into the early continent is the first record of a series of oscillations in which land and sea successively occupied the area of America. In pre-Cambrian time the continent we are considering sunk, leaving some of its mountain tops, as islands, and the neighboring oceans flowed over it, their bottoms emerging and becoming continents. This is a second of the recorded oscillations of the first magnitude.

After Archæ-America had begun to sink and its bounding land masses to emerge, the conditions on the two sides of the ocean began to show characteristic difference of behavior —difference in the rate of subsidence—that very difference of rate which Uniformitarianism denies.

Palæ-Pacifis and Palæ Atlantis were land areas which I conceive to be of continental magnitude from the vast volumes of sediment brought down by their rivers and poured into the Palæ-American Ocean. American geologists have found the record along the eastern margin of that ocean, namely, the present Appalachian region, so legible that they are agreed as to its main features. There is no plea of illegibility here. The total sediment which fringed the shore of Palæ-Atlantis was about 45,000 feet in maximum, but the original ocean, when strata began to gather, was not 45,000 feet deep. That depth and the full accumulation of beds was arrived at by successive subsidences of the sea bottom. The Primordial or earliest Palæozoic along the eastern shore shows evidence of shallow water, which deepened by the occasional sinking of the sea floor. This periodic subsidence went on through the whole Palæozoic time, iufluencing the Appalachian region, and during the whole coal bearing period affecting the sea bottom as far as Kansas. Shallow water evidences are common up to the Carboniferous, after which successive low-level land areas repeatedly occupied the east half of the present Mississippi basin.

OCEAN BEDS UPLIFTED.

This immensely long history of periodic but general subsidence was broken in the northeast by several sudden uplifts, in which the sea strata was so disturbed and inclined that the succeeding beds rested on them unconformably, and in one instance the Green Mountain range was upheaved. The general law on the east side of the Palæ-American Ocean has been the continual inpouring of sediment from Palæ-Atlantis, subsidence of sea bottom, repeated a great number of times, and only locally varied by dislocation and uplifts. A very limited but not unimportant chapter has just been added to the American rock record by the geological exploration of 40th parallel; it is the mode of deposition of the Palæozoic rock in Western United States.

Passing now to the western side of the ocean, we have again the same enormous thickness of 30,000 or 40,000 feet of Palæozoic beds, but from bottom to top no evidence of disturbance, only uniform proof of deep oceanic deposition. In other words, the two sides differ: one went down by gradual and successive subsidence, the other at once sunk so as to form a profound ocean, which, from beginning to end of the vast Palæozoic age, received in its quiet depth the dust of a continent and the debris of an ocean life. I do not say that the western ocean bottom never suffered further subsidence. I only assert that between the two sides the difference of rate was simply immense.

In keeping with the minor and slight movements of subsidence in the east are the changes in the materials of the gathering strata, which are found to vary continually. Here again the contrast between the east and west is marked. All the Palæozoic series in the west consist in the main of a few broad changes between quartzitic and limestone beds, both giving evidence of deep-sea deposition. By way of illustrating these changes of material, let us consider the condition of the sedimentation at the west during the Carboniferous age. There we have 7,000 feet of limestone, for the most part quite free from land-detritus, accumulated with all the evenness and regularity which the most ardent Uniformitarian could ask, suddenly followed by an equal amount of pure land-detritus almost free from lime. This sudden change of sediment, simply means a sudden physical change, either a cosmical one which recorded itself as a cycle of climate productive of great eroism, or a terrestrial change resulting in such great disturbance of distant land and sea areas as to cause new climate or new avenues of drainage, or some remote coast disturbance which brought about a revolution of oceanic currents. In either case the sudden change, both at the beginning and end of the quartzite period, and the vast scale of the deposit, means a change of rate in the current operations of nature, and an enormous change of rate. The abrupt passage from a period in which little or no land detritus has entered a sea for millions of years, to one when it pours in with relatively marvelous rapidity is certainly not Uniformitarian. This phenomenon of sudden change in the broad petrographical features of a composite group of strata is equally true of each sudden break, of which the western Palæozoic has six. Recall that

* An address delivered before the Sheffield Scientific School, Yale College, New Haven, Conn., June 26, 1877, as reported in the *New York Tribune*.

the bottom of all this ocean was a former continent, that along the east the continent went down gradually, by con siderable steps, it is true, but still by periodic and, perhaps, gradual subsidences. If the Uniformitarians can derive any comfort from Eastern America, and I suppose they justly may, they are welcome to it. The rate of subsidence in the East, although not unlikely to have been catastrophic as regards the life of the disturbed region, looked at broadly, may be called uniformitarian. That on the West was distinctly catastrophic in the widest dynamic sense.

AMERICA FORMED BY CATASTROPHES.

Let us pass now to a remarkable chapter of events which close the Palæozoic ages. What is now the eastern half of the Mississippi Basin had through the coal period, often extended itself as a land mass as far west as the Mississippi River, and had as often suffered subsidence and resubmergence. To the west, however, still stretched the open ocean, which, since the beginning of the Cambrian, had, with a single exception, never been invaded by land. At the close of the Palæozoic the two bordering land areas of the Atlantis and Pacifis, since the beginning of the Cambrian permanent and perhaps extending continents, began to sink. They rapidly went down, and at last completely disappeared, their places being taken by the present Atlantic and Pacific oceans, while the sea-floor of the American ocean, which had been for the most part permanent oceanic area ever since the submergence of the Archæan America, emerged and became the new continent of America, which has lasted with local vicissitudes up to the present. The east and west were, indeed, separated by a mediterranean sea, the sole relic of the American ocean which now occupied a narrow north and south depression.

In that mediterranean sea, we may say that the conditions have been uniformitarian; that is to say, in the great post-Palæozoic catastrophe that ocean was spared. It remained a body of deep water, its bottom undisturbed by folds or dislocations, and there is no evidence of a cessation of sediments; yet the species which lived there throughout the vast length of the coal period were completely extinguished, and entirely new forms made their appearance. Although spared from the actual physical catastrophe, the effect of the general disturbance of that whole quarter of the globe was thoroughly catastrophic, and exerted a fatal influence upon life far beyond the actual theater of upheaval.

Passing over the Mesozoic age, which in detail offers much instructive material as to rate of change, we pause only to notice a catastrophe which marked the close of that division of time.

In a quasi-uniformitarian way, 20,000 or 30,000 feet of sediment had accumulated in the Pacific and 14,000 in the mediterranean sea; when these regions, which, during their reception of sediment, had been areas of subsidence, suddenly upheaved, the doming up of the middle of the continent quite obliterating the mediterranean sea and uniting the two land masses into one.

The catastrophe which removed this sea resulted in the folding up of mountain ranges 20,000 and 40,000 feet in height, thereby essentially changing the whole climate of the continent. Of the land life of the Mesozoic age we have abundant remains. Thanks to the palæontologists, the wonderful reptillian and avian fauna of the Mesozoic age is now familiar to us all. But after the catastrophe and the change of climate which must necessarily have ensued, this fauna totally perished. The rate of this post-Cretaceous change was, in other words, catastrophic.

During the Tertiary, fresh water lakes of wide extent have occupied the western half of the continent. Such was the character of the great post-Cretaceous uplift that there were left broad, deep continental basins above the level of the sea. Into these the early Tertiary rivers found their way, creating extended lakes in which accumulated strata rivaling in importance the deposits of the great oceans. The whole history of the Tertiary is that of the accumulation of thick sedimentary series in fresh water lakes, accompanied by gradual and periodic subsidence, carried on smoothly and uniformly up to a certain point, and then interrupted by a sudden, mountain-building upheaval, which drained the lakes and created new basins. The five minor catastrophes which have taken place in the western half of America during the Tertiary age have never resulted in those broader changes which mark the close of the Archæan, the Palæozoic, and the Mesozoic ages. They never broke the grander outlines of the continent. They were, however, of such an important scale as to very greatly vary the conditions of half the continent. I may cite the latest important movement, which took place probably within the human epoch, certainly at the close of the great Pliocene lake period of the west. The whole region of the great plains, as far north as we are acquainted with their geology, and southward to the borders of the Gulf, was occupied by a broad lake which existed through the Pliocene period, having always a subtropical climate. In that lake, beds 1,000 to 1,200 feet thick, had accumulated, when suddenly the level floor was tilted, causing a difference of height of 7,000 feet between the south and west shores, making the great inclined surface of the present plains, and utterly changing the climate of the whole region. Not a species survived.

FIELD RECORDS OF CATASTROPHES.

I have thus hastily mentioned a few of the most important geological crust-changes in America whose rates are demonstrably catastrophic. Besides surface changes, involving subsidence, upheaval, faulting and corrugation, all of which may be executed on a scale or at a rate productive of destruction of life, catastrophes may be brought about by sudden, great changes of climate, or by intense volcanic energy. In the latter field there are obviously no catastrophes of the first order. Geological maps of the globe have progressed far enough to demonstrate that considerable areas are, and always have been, free from actual ejection of volcanic materials. On the contrary, numerous great regions, notably the western third of our own continent and the shores of the Pacific, were once literally deluged with volcanic fires. An examination of the ejected rock shows that modern eruptions, by which the volcanic cones of the present period are slowly built up from slight overflows piling one upon another, is not the method of the great Miocene and Pliocene volcanic periods. There were then outbursts hundreds of miles in extent, in which the crust yawned and enormous volumes of lava rolled out, overwhelming neighboring lands. Volcanoes proper are only isolated chimneys, imposing indeed, but insignificant when compared with the gulfs of molten matter which were thrown up in the great massive eruptions. Between the past and present volcano phenomena there is not only a difference of degree but of kind. It is easy to read the mild exhibition of existing volcanoes as a uniformitarian operation, namely, the growth of cones by slight accretions; but such reasoning is positively forbidden in the past.

If poor, puny little Vesuvius could immortalize itself by burying the town at its feet, if the feeble energy of a Lisbon earthquake could record itself on the gravestones of thousands of men, then the volcanic period in western America was truly catastrophic.

Modern vulcanism is but the faint flickering of survival of what was once a world-wide and immense exhibition of telluric energy, one whose distortions and dislocations of the crust, whose deluges of molten stone, emissions of mineral dust, heated waters, and noxious gases could not have failed to exert destructive effect on the life of considerable portions of the globe. It cannot be explained away upon any theory of slow, gradual action. The simple field facts are ample proof of the intensity and suddenness of tertiary vulcanism.

Of climatic catastrophes we have the record of at least one. When the theory of a glacial period came to be generally accepted, and the destructive effects of the invasion of even middle latitudes by polar ice were realized, especially when the devastating effects of the floods which were characteristic of the recession of the ice came to be studied, uniformitarianism pure and simple received a fatal blow. I am aware that British students believe themselves justified in taking uniformitarian views of the bowlder-till, but they have yet to encounter phenomena of the scale of our Quarternary exhibitions.

A most interesting comparison of the character and rate of stream erosion may be obtained by studying, in the western Cordilleras, the river work of three distinct periods. The geologist there finds preserved and wonderfully well exposed: first, Pliocene Tertiary river valleys, with their bowlders, gravels, and sands still lying undisturbed in the ancient beds; secondly, the system of profound cañons from 2,000 to 5,000 feet deep, which score the flanks of the great mountain chains, and forms such a fascinating object of study, and not less of wonder, because the gorges were altogether carved out since the beginning of the glacial period; thirdly, the modern rivers, mere echoes of their parent streams of the early Quarternary age. As between these three, the early Quarternary rivers stand out as vastly the most powerful and extensive. The present rivers are utterly incapable, with infinite time, to perform the work of glacial torrents. So, too, the Pliocene streams, although of very great volume, were powerless to wear their way down into solid rock thousands of feet, at the rapid rate of the early Quarternary floods. Between these three systems of rivers is all the difference which separates a modern (uniformitarian) stream and a terrible catastrophic engine, the expression of a climate in which struggle for existence must have been something absolutely inconceivable when considered from the water precipitations, floods, torrents, and erosions of to-day.

Uniformitarians are fond of saying that give our present rivers time, plenty of time, and they can perform the feats of the past. It is mere nonsense in the case of the cañons of the Cordilleras. They could never have been carved by the pigmy rivers of this climate to the end of infinite time. And, as if the sections and profiles of the cañons were not enough to convince the most skeptical student, there are left hundreds of dry river beds within whose broad valleys, flanked by old steep banks and eloquent with proofs of once-powerful streams, there is not water enough to quench the thirst even of a Uniformitarian. Those extinct rivers, dead of drouth, in connection with the great cañon system, present perfectly overwhelming evidence that the general deposition of aerial water, the consequent floods and torrents, forming as they all do the distinct expression of a sharply-defined cycle of climate, as compared either with the water phenomena of the immediately preceding Pliocene age, or with our own succeeding condition, constitute an age of water catastrophe whose destructive power we only now begin distantly to suspect.

UNIFORMITARIANISM DISPROVED.

I have given you what in my belief are sound geological conclusions, the want of time alone causing me to waive the slow production of proofs. I believe I am fully prepared to sustain the assertions: first, that the rate of physical change progressing to-day in all departments of terrestrial action is inadequate to produce the grander features of American geological history; secondly, that in the past, at intervals, the dynamic rate has been so sharply accelerated as to bring about exceptional results; thirdly, that these results have been catastrophic in their effect upon the life of America and the bounding oceans. I have called the revolution in the American area catastrophic because any disturbances of land or sea, of the described scale, intensity and rapidity could not fail to have a disastrous effect on much of the organic world. The Uniformitarian school would accept these crust-changes with unruffled calmness; they would read the record exactly as a Catastrophist might, only they would assume unlimited time and their inch-by-inch process. The analogy of the present, they say, is against any acceleration of rate in the past, and besides, the geological record is a very imperfect document which does not disprove our view. In plain language, they start with a gratuitous assumption (vast time), fortify it by an analogy of unknown relevancy (the present rate), and serenely appeal to the absence of evidence against them, as proof in their favor. The courage of opinion has rarely exceeded this specimen of logic. If such a piece of reasoning were uttered from a pulpit against evolution, biology would at once take to her favorite sport of knuckle-rapping the clergy in the manner we are all of us accustomed to witness. In forbidding us to look for past rates of change differing from the present, the British Uniformitarians have tied the hands of the science. By preaching so eternally from the text of "imperfection of the geological record," they have put blinders on the profession. A few more such doctrines will reduce the science to a corpse, around which teleologists and biologists might hold any sort of funeral dance their fancy dictated. Now, because the record is not altogether made out, is no proof whatever that it never will be. There was once a discovery of a very small piece of evidence, the Rosetta Stone, which served as a key to a vast amount of previously illegible material. Geology, if not strained in its own house, will, in my belief, go on and dig up enough Rosetta Stones to translate the strata into a precise language of energy and time.

As yet, we have no means, beyond mere homotaxial comparison for relating the crust movement of distant regions. I do not, however, despair of our being able to correlate the movements and revolutions of different continents. At present, while old fashioned catastrophes, involving repeated world-wide destruction of all life, such cataclysms as Cuvier believed in, and which occasioned the revolt of the biologists of his time, are justly repudiated. On the other hand, the mild affirmations of the Uniformitarians, that existing rates of change and indefinite time are ample to account for the past, are flatly and emphatically contradicted by American facts. With our present light, geological history seems to be a dovetailing together of the two ideas. The ages have had their periods of geological serenity, when change progressed in the still, unnoticeable way, and life through vast lapses of time followed the stately flow of years, drifting on by insensible gradations through higher and higher forms, and then all at once a part of the earth suffered short, sharp, destructive revolution unheralded as an earthquake or volcanic eruptions. The sciences are as independent as bodily organs; they are the vitals of human knowledge. A fallacy lodged in one produces functional disturbance of the others. It was the error of universal and extreme catastrophes which so violated the conceptions of Lamarck, Goethe, and St. Hilaire as to draw out their earnest protest, and as usual they urged the pendulum past the golden mean of truth over to the counter error of extreme Uniformitarianism. This latter error has been confidently built in as one of the corner-stones of the imposing structure of Evolution. I believe the crumbling, valueless nature of this foundation will yet make itself felt in the ruin of just so much as the builders have rested upon it.

CATASTROPHE AND EVOLUTION.

If the vicissitudes of our planet have been as marked by catastrophes as I believe, how does that law affect our conceptions of the development of life and the hypothesis of Evolution? Man, whatever the drift of life or philosophy, returns with restless eagerness, with pathetic anxiety to the enigma of his own origin, his own nature, his own destiny. With reverence, with levity, with faith, with doubt, with courage, with cowardice, by every avenue of approach, in every age, the same old problem is confronted. We pour out our passionate questionings, and hearken lest mute Nature may this time answer. But Nature only yields one syllable of reply at a time.

Darwin, who in his day has caught the one syllable from Nature's lips, advances always with caution, and although he practically rejects, does not positively deny, the existence of sudden great changes in the earth's history. Huxley, permeated in every fiber by belief in Evolution, feels that even to-day Catastrophism is not yet wholly out of the possibilities. It is only lesser men who bang all the doors, shut out all doubts, and flaunt their little sign, "Omniscience on draught here." It must be said, however, that biology, as a whole, denies Catastrophism in order to save Evolution. It is the common mistake of biologists to assume that catastrophes rest for their proof on breaks in the palæontological record, meaning by that the observed gaps of life, or the absence of connecting links of fossils between older and newer sets of successive strata. There never was a more serious error. Catastrophes are far more surely proved by the observed mechanical rupture, displacement, engulfment, crumpling, and crushing of the rocky surface of the globe. Granted that the evidence would have been slightly less perfect had there been no life till the present period, still the reading would have been amply conclusive. The palæontological record is as imperfect as Darwin pleads, but the dynamic record is vitiated by no such ambiguity.

It is the business of geology to work out the changes of the past configuration of the globe and its climate, to produce a series of maps of the successive stages of the continents and ocean basins, but it is also its business to investigate and fix the rates of change. Geology is not solely a science of ancient configuration. It is also a history of the varying rates and mode of action of terrestrial energy. The development of inorganic environment can and must be solved regardless of biology. It must be based on sound physical principles, and established by irrefragible proof. The evolution of environment, a distinct branch of geology, which must soon take form, will, I do not hesitate to assert, be found to depend on a few broad laws, and neither the Uniformitarianism of Lyell and Hutton, Darwin and Haeckel, nor the universal Catastrophism of Cuvier and the majority of teleologists, will be numbered among these laws. In the dominant philosophy of the modern biologist there is no admission of a middle ground between these two theories, which I, for one, am led to reject. Huxley alone among prominent evolutionists opens the door for a union of the residua of the two schools, fusing them in his proposed Evolutional Geology. Looking back over a trail of thirty thousand miles of geological travel, and after as close a research as I am capable, I am impelled to say that his far-sighted view precisely satisfies my interpretation of the broad facts of the American continent.

The admission of even modified catastrophe, namely, suddenly-destructive, but not all destructive change, is, of course, a downright rejection of strict Uniformitarianism. I comprehend the importance of the position, how far-reaching and radical the logical consequences of this belief must be. If true, it is nothing less than an ignited bomb-shell thrown into the camp of the biologists, who have tranquilly built upon Uniformitarianism, and the supposed imperfection of the geological record. I quote a few of their characteristic utterances. Lamarck, in his "*Philosophie Geologique*," 1809, says: "The kinds or species of organisms are of unequal age, developed one after another, and show only a relative and temporary persistence. Species arise out of varieties. . . . In the first beginning only the very simplest and lowest animals and plants came into existence; those of a more complex organization only at a later period. The course of the earth's development, and that of its organic inhabitants was continuous, not interrupted by violent revolutions. . . . The simplest animals and the simplest plants, which stand at the lowest point in the scale of organization, have originated and still originate by spontaneous generation." Darwin, "Origin of Species," p. 522, says: "We must be cautious in attempting to correlate as strictly cotemporaneous two formations, which include few identical species, by the general succession of their forms of life. As species are produced and exterminated by slowly acting and still acting causes, and not by miraculous acts of creation and by catastrophes. . . . And again, for my part, following out Lyell's metaphor, I look at the natural geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page only here and there a few lines. Each word of the slowly changing language in which the history is written, being more or less different in the successive chapters, may represent the apparently abruptly changed forms of life entombed in our consecutive but widely separated formations. On this view, the difficulties above discussed are greatly diminished, or even disappear."

(*To be continued.*)

THE BLACK POPLAR TREE.

The Black Italian Poplar (*Populus Monilifera*) is well known to be one of our fastest-growing forest trees, the timber of which is much used in constructive work where toughness and moderate elasticity combined are required. The tree is a native of North America, and is said to have been first brought to Italy, and thence to Britain; hence the common name "Black Italian poplar." It was first introduced into this country from Canada in 1772, and Loudon, in writing of it some half-century ago, says: "Its rate of growth in the climate of London, in good soil, is between thirty and forty feet in seven years, and in Scotland it has attained the height of seventy feet in sixteen years." Such rapid growth it is not likely to make in all cases, but there is a growing knowledge of the usefulness of the timber and the profitableness of the tree as a forest crop, and we have every confidence in recommending it to the attention of planters as a most valuable tree where the soil and climate are suitable to its nature. In corroboration of our opinion, we have much pleasure in quoting the following letter from Mr. McLaren, the highly experienced and intelligent forester to the Earl of Hopetoun, Hopetoun House, Linlithgow. He says: "I am pleased to send you a few particulars about a fine black Italian poplar, containing eighty cubic feet of timber, which was cut down here last December. It was planted, in 1824, in a mixed plantation of ash, elm, oak, maple, poplar, larch, and Scots fir; and after being cut down was sold at our public sale for £8 12s. 6d., being more than double the price received for any of the other kinds at the same age; the larch approaching nearest to it in size, and the price per tree it brought. It may be said that the soil suitable to free growth of the poplar does not suit the other sorts; but while it was planted in a damp spot peculiar to its healthy growth, the others were planted upon higher and dryer ground more congenial to their nature, so that they were upon equal terms in that respect. Another thing in favor of the black Italian poplar is, that from its upright habit of growth it can afford to stand closer upon the ground than any other common hardwood tree, and requires little or no pruning, naturally forming a straight and clean bole.

"It would be no great stretch of imagination to suppose that a Scotch acre would produce seventy trees worth £5 each in fifty years, which would yield a rental of £7 per acre per annum for that period, the thinnings and periodical cuttings having already paid the cost of planting and management."—*Journal of Forestry.*

TREE LEAVES AS FERTILIZERS.

The chemists of the German Arboricultural and Agricultural Schools have made a thorough investigation into the properties and composition of forest tree leaves. They have found the chemical analysis of the leaves of several species of forest trees to be much richer in phosphates and other fertilizing ingredients than they generally get credit for in this country, so much so that we would call the attention of all interested in their value as excellent litter when collected and kept dry till used, and the valuable manure they make, according to analysis given by the German chemists. The following table of the constituents of beech, pine, and spruce leaves is taken from some recently published reports of investigations made in Bavaria, and for comparison we add to it the quantity of the various ingredients contained in a ton of wheat straw. It will be seen that beech leaves are fully as rich in fertilizing matter as wheat straw, and that pine and spruce leaves are very little inferior to it.

Annual Produce of Leaves from an acre of Forest, and its composition compared with that of a ton of Wheat Straw.

	Dry Matter.	Ash.	Potash.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.
	lbs.						
Beech	2,972	165·5	1·80	73·18	10·90	9·32	3·23
Pine.... ...	2,842	41·5	4·32	16·84	4·28	3·28	1·51
Spruce ..	2,083	121·3	4·30	57·37	6·20	5·72	1.87
Wheat Straw	2,240	85·2	9·80	5·20	2·20	4·60	2·41

LEAVES OF THE BUTTON SNAKE ROOT.

An extensive demand for the dry leaves of the button-snake root (*Liatris odoratissima*) has arisen among perfumers and tobacconists in the United States, and a subscriber of the *Chemist and Druggist* gives the following particulars regarding it: The "wild vanilla," as it is commonly called, and more vulgarly "hound's" tongue or deer tongue, is found in East and South Florida, and portions of lower Georgia. It grows abundantly on the edges of what are called "bays," *i. e.*, low, swampy places in the pine woods, which are partially grown over with bays (a species of magnolia). The odor of the leaves strongly resembles the real vanilla. Most of the species of *Liatris* or button-snake root have a tuber-like root and long straight stems, upon which the numerous flower-heads are crowded in a close spike. A number of these are cultivated as ornamental plants. In *L. odoratissima* the lower leaves are from eight to twelve inches long, by two to three broad; the upper ones very small. The stem divides above into a broad branching panicle of purple flowers, which makes the plant a very attractive one. The fresh leaf has, when crushed, a disagreeable odor, but when pulled from the plant and dried in the shade for a day or so, it becomes highly fragrant, having a smell resembling vanilla or tonka bean, and similar to the sweet-scented vernal grass, but much stronger. This odor is developed by some chemical change made in the leaf during the process of drying, whereby the peculiar principle known as coumarine is formed.

Coumarine is found abundantly in the tonka bean of commerce, but so abundant is it in the liatris that it is often found in large quantities on the upper portions of a mass of the semi-dried leaves. It is readily sublimed by a low degree of heat (150°), and the heat generated in these masses or bundles is sufficient to sublime it on the upper or cooler layer. When found in this way, coumarine is composed of snow-white, needle-shaped crystals, exceedingly fragrant, the leaf looking as though it had been out all night in cold, frosty weather.

The dried leaves, as before mentioned, furnish an article of commerce, and one that is steadily growing in importance. They are gathered principally on the St. John's River and its tributaries by the poorer people, and sold by them in small lots to the country storekeeper in exchange for goods; by these latter they are sent to the balers and packers, who forward them to New York for home use and exportation. Pilatka, on the St. John's River, is the headquarters of the trade. One may often see 75 or 100 bales of 200 lbs. each lying on the wharves awaiting shipment. One dealer at this place has received an order for as large a quantity as 150,000 lbs. Adults can gather from 150 to 400 lbs. of the green leaves in a day; active boys and girls nearly as much. The green leaves are taken home and dried in the shade, and lose about 80 or 85 per cent. in weight; they are then sold for from three to six cents. per lb., yielding quite a good return for the laborer. The packer bales and ships, and realizes from eight to twelve and a half cents per lb. The dried leaves are used to give a flavor to cigars, snuff, and smoking tobacco. For cigars it is sufficient to place the leaves and cigars in alternate layers in a box, and allow the whole to remain together for several days; for snuff the leaves are dried, ground, and mixed; they are mixed with smoking tobacco after being shredded up or granulated. A small quantity is sufficient to flavor a large mass of tobacco. Their odor is given off much more intensely on a damp day than on a dry one. Although large quantities of these leaves are consumed in America, a much larger quantity is shipped to France and Germany, where they are rapidly growing in favor. It is quite probable they will soon be used much more extensively by perfumers, and as they are known to keep the "wicked moth away," they may use fully replace the strong-smelling camphor and tobacco stems.

IMPROVING PASTURES.

Many farmers pay their pastures but little attention aside from keeping the fences in repair. No other part of the farm is expected to yield a crop, year after year, without some compensation in the form of fertilizers, and it is a fallacy to suppose that any pasture will continue to feed a given number of cattle when its fertility, or rather its food-producing capacity, is constantly decreasing from an annual consumption and final exhaustion of its mineral elements.

Land is not so much injured by depasturing as by constantly mowing it. Still it requires manuring, for every head of cattle that feeds upon its growth consumes the phosphate in the soil as well as the nitrogenous elements necessary in the formation of bone, fat, muscle, and milk, and the richer the feed the more rapid and profitable the growth of the animal. No thrifty farmer would think for a moment of feeding his cattle in the barns, during the winter months, with a quantity of food diminishing year by year, yet this is the policy pursued in the management of pastures.

The excrement that grazing animals returns to the soil bears but a small proportion to the elements they take from it, since one thousand pounds of excrement contains but four pounds of nitrogen, three pounds of phosphoric acid and four of lime, while the same proportion of bone of such animals contains fifty pounds of nitrogen, two hundred and forty of phosphoric acid, and three hundred and thirty of lime, all of which must have been extracted from the soil at one time and another. Hence, to raise fine and healthy stock, such elements must again be restored to the soil and an application of bone manure, in the shape of superphosphate or some other form, is absolutely essential. Gypsum is especially good for promoting the growth of clover. It is believed that gypsum acts far more through its sulphuric acid than through its lime, since all soils contain more or less lime, though not of the acid; and that sulphuric acid acts as an absorbent of the ammonia in the air, likewise as a producer of ammonia, by setting it free from the insoluble humus of the ground. Different soils may receive undoubted benefit from judicious application of ashes, lime, soot, charcoal dust, and the like.

Grasses and clover receive nearly ninety-four per cent. of their growth from air and rain, and are dependent upon the soil for only about six per cent. of mineral substance. In a state of nature they would, by decay and mulching, preserve the fertility of the soil on which they grow, but the increased demand consequent upon grazing the land renders an artificial supply of mineral constituents an imperative necessity. As cattle feed most from the rich spots in a pasture and spend most of their time in shady, sheltered resting-places, it follows that their excrements are very unevenly distributed, and their droppings should be frequently knocked and spread about. Again, wherever the herbage starts up so rank as to be left by grazing animals, such spots should be mowed every week, since the cattle may frequently be tempted by the dry hay; new and succulent growth will be induced, and, even if neglected, the mowings will serve as a mulch in promoting the growth of the grass roots during a dry season.

The pleasant, easy-going, careless method of farming, simply to sow and merely to reap, to stock the land and depend upon Dame Nature to supply the herbage, is gradually giving way to the more rational and intelligent mode of mixing thought and brains with this occupation; of taking advantage of the discoveries and investigations of the patient students of science, about which our predecessors knew nothing. Progress and profit will follow in the footsteps of intelligent thought and industrious action.—*American Cultivator.*

SHALL COUNTRY HOUSES HAVE CELLARS?

The editorial in the *Reporter*, on domestic architecture in its sanitary relations, has brought us several letters on the subject, one of which, by Dr. A. Haddon, of New York, broaches the question whether country houses should or should not have cellars. The cellar is a survival of the "hole in the ground" in which our ancestors of the stone age used to hide their valuables. The kind of a cellar most prized in the country is one cool and damp in summer, and comparatively warm in winter. In many portions of the country it has a spring or well in it, or an artificial stream of water is conducted through it, in order to keep the milk cool and the air moist. Vegetables, butter, and fruits keep better in such an atmosphere. During the winter the cellar is not ventilated, as the entrance of the outside air would reduce the temperature below the freezing point, and injure the potatoes, apples, carrots, and other products of the garden and farm there stowed. Not unfrequently some of these undergo the dry rot, or are attacked by decomposition in other forms. The air of the cellar penetrates the dwelling and sleeping rooms, and is breathed by the family.

That phthisis may be produced in such an atmosphere is unquestionable; also, that it aids in developing any constitutional disease that may lie dormant in our system by lowering vitality. It certainly, also, renders the progress of any of the contagious diseases less favorable and more difficult in treatment. It is really an atmosphere that produces the morbid influences which beget such diseases as above named.

Now it must be granted that there are no greater necessities to farmers and gardeners than good cellars. They are as indispensable as barns and granaries. They are places in which vegetables and many other articles of produce can be more conveniently kept, and at less expense than any others. They are the refrigerators in summer, and the conservatories in winter. In well kept and highly valued ones the temperature does not rise higher than fifty degrees Fahrenheit in summer, nor fall below thirty-five degrees in winter, and has always a sufficient degree of moisture to prevent the shrinkage of either vegetables or wooden vessels that may be there stored. The necessity and utility of these parts of the household being settled, the question arises: Where shall we locate them and fulfill the conditions, and how shall the under surface of dwellings be made better and more healthy? Dr. Haddon recommends that the apartment be made under some convenient outhouse, either the barn, carriage or wood house; under any of these buildings the convenience can be made as perfect as under the dwelling, and the security against loss and damage of any article stored therein can be as full as one may desire; besides, all earth and *débris* which commonly accompany such articles are kept away from the dwellings, a consideration truly of some merit. The experiment of having cellars located in this manner has already been tried, and found in every respect satisfactory, but they have not been ruled out from the dwelling and these entirely substituted.

In answer to the question, How are we to better the condition of the under part of the dwelling, and make it more healthy? he urges the plan that the structure be built on the ground, not into it. The foundation should be built of some imperishable material (stone or brick), and laid below the lowest frost line in the earth, and the surface within the foundation be concreted in such a manner that neither moisture can be absorbed nor insects and animals burrow; raised a little at the centre, so that fluids or any other substances may fall toward the outer lines; the foundation to rise sufficiently high to allow clearing underneath to be easily done; to have openings of large size in all sides, to admit air freely, and allow easy access through to any who have reason to enter. These also to have the means of being securely closed when necessary, either at night or during inclement seasons

Any one acquainted with the theories of the eminent hygienist, Pettenkofer, and the very deteriorating influences he ascribes to "ground air," will see how appropriate and just are Dr. Haddon's recommendations, and we trust they will not fall unheeded on the attention of the profession.—*Med. and Surg. Reporter.*

LAWNS—HAY.

What is the best fertilizer for the recovering exhausted lawn grass—something that will not deface the lawn, and be immediately effective? (1) In mowing hay in an open lawn, how green may I venture to mow it? I wish to preserve its color, and retain the most nutriment? (2) [1. Superphosphate, on soils which are benefitted by it, has produced good results; guano would be likely to be beneficial; fine pulverized compost, or old manure broken fine, would always be useful. 2. It is difficult to answer this question definitely, and farmers of experience think they can guess pretty accurately whether hay is dry enough to keep well. The degree of dryness would vary with damp or dry summers, and with grass cut early or late. Late cut grass is stiffer, does not settle so solid, contains less water, and would dry more rapidly in mass. There is a certain point when hay would retain for months most of the moisture with which it is stored; with more moisture it would heat and ferment, and, by expelling the water by the heat, retain less than hay which does not heat. It would be interesting and useful to dry hay to different points, weigh it accurately, and determine, by inspection and weighing months afterwards, what is the most profitable percentage of moisture for it to hold when stored in the barn.]—*Country Gentleman.*

THOROUGHBRED PIGS.

Successful farming in the future must combine intelligent thought with industrious effort. Competition has reduced the producer's profit to such a narrow margin that no false step can now be taken with impunity. No thrifty farmer should subject himself to the positive loss so certain to accrue from feeding coarse, scrubby, large-boned animals, whether oxen, sheep or pigs; and yet millions of such creatures are maintained in this country, consuming the substance of their owners and bringing into bad repute the great business of meat production.

In New England, especially, where so much of the food for animals must be purchased from abroad, it is absolutely essential to successful pork-raising that such pigs only should be reared as will give the largest returns for the smallest amount of food; such as combine with the small bones, little offal, early maturity, and rapid fattening qualities. To produce this desirable result it is only necessary to procure reliable thoroughbred sires of some approved and established breed, and cross them with large, healthy, and vigorous sows of common stock. Such crosses will furnish grade pigs that will assimilate more food and grow more rapidly than pure-bred animals.

The thoroughbred pig is the result of many years of intelligent, scientific, and experienced breeding; of high feeding and extra care; of close selection, generation after generation, of those individual members of the purest herds who exhibited in marked degree the qualities of rapid growth, early maturity, and profitable assimilation of food. After fully establishing these qualities in the breed, the high-bred pig is principally valuable for his power of transmitting such qualities to his offspring, when crossed with selected ordinary sows. No farmer can afford to keep a herd of high-bred pigs simply for the purpose of raising pork for the butcher, and the rearing of such by the average producer for any other purpose than that of improving his common stock cannot be recommended.

When, however, the fact can be demonstrated, beyond a question, that, by using reliable thoroughbred sires, every pig in the litter will be worth at least one dollar a head more when weaned, and can, with an equivalent amount of food, in twelve months be made to weigh fifty to eighty pounds more than the scrub, adding a money value of three to five dollars to each pig in favor of the grade, is it not the part of plain business sagacity and intelligent farming to adopt that course which leads to certain success? A few years since, owing to their scarcity in this country, thoroughbred pigs of approved breeds were held at prices far above the reach of ordinary farmers, but now, thanks to the enterprise and intelligence of our American breeders, such pigs are within the purchasing power of a vast majority of our farmers, who should take advantage of such opportunities and make pork-raising an additional source of profit in the economy of the farm.—*Boston Cultivator.*

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